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JOURNAL OF DAIRY SCIENCE

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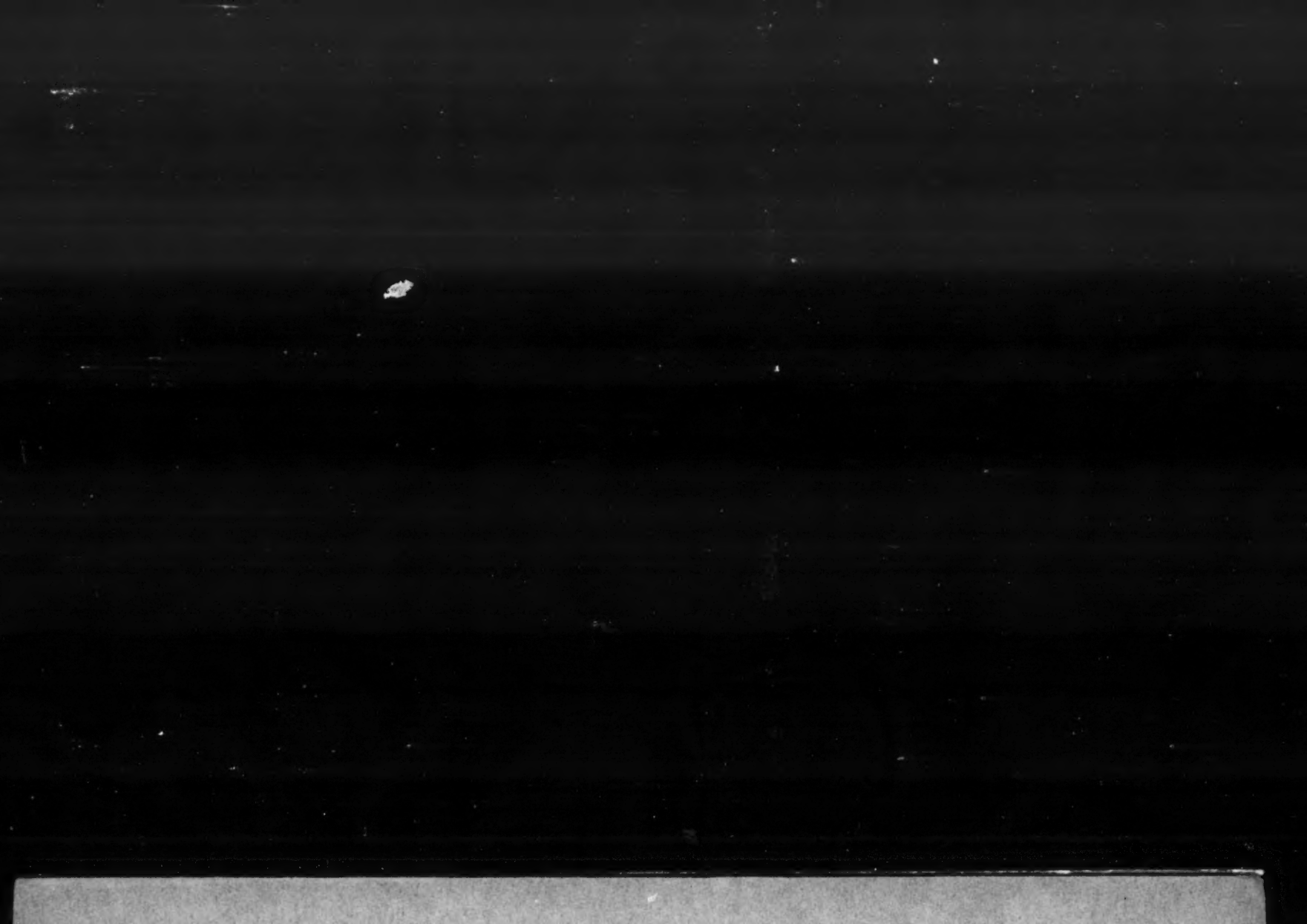

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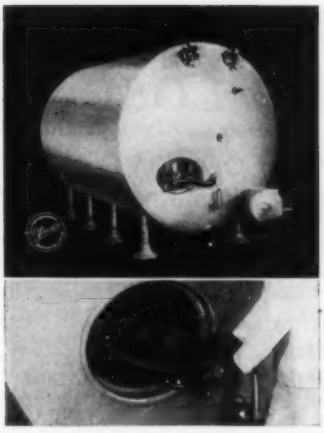

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JOURNAL OF DAIRY SCIENCE

VOLUME XXI NOVEMBER, 1938 NUMBER 11

EFFECT OF SHAKING ON THE LIPOLYSIS OF COW'S MILK[1]

V. N. KRUKOVSKY AND PAUL F. SHARP

Department of Dairy Industry, Cornell University, Ithaca, New York

INTRODUCTION

Eufinger (10) showed that the titratable acidity of human milk increased several fold as a result of shaking for a few hours, and that the increase was associated with the presence of fat since the acidity did not increase when skimmilk was shaken. He found further that the increase in acidity was slight when cow's milk was shaken, and concluded that this difference could be used to distinguish between cow's and human milk. Engel (8, 9) was loath to accept the idea that the increase was the result of lipase action, because usually enzymes are inactivated by shaking. Davidsohn (5), Behrendt (2, 3), Schlossmann (19), and Freudenberg (11) concluded that shaking activated the enzyme or cleared the surface of the fat globules for action. A difference in the effect of shaking on the increase in acidity of cow's and human milk was noted by Eufinger (10), Davidsohn (5) and Behrendt (2), and the two last named investigators observed a marked alteration in surface tension as a result of shaking human milk. Krukovsky and Sharp (14) found a marked increase in titratable acidity due to lipolysis during the churning of raw cream separated from the milk of certain cows in advanced lactation. This result indicated that the lipase of cow's milk could be activated by shaking, and that shaking could be used as a method for activating and studying the true lipase of milk. Some of the results obtained are presented in this paper.

Paraschtschuck (18), Eckles and Shaw (7), Palmer (17), Sharp and de Tomasi (20), Csiszár (4), Hileman and Courtney (13), Anderson (1), Krukovsky and Sharp (14) and others have shown the marked lipolytic activity of milk from certain cows, particularly those in advanced lactation.

Most of these investigators are of the opinion that some other factor in addition to advanced lactation is necessary for the production of milk in which the lipase is naturally active. This contributing factor may be temperature, season, feed, or some other factor affecting the physiology of milk secretion or its composition.

Received for publication May 4, 1938.

[1] We are indebted to the Joseph Willmann Dairy Research Fund for a grant in aid of this investigation.

EXPERIMENTAL

The method consisted in the determination of the increase in titratable acidity expressed as percentage lactic acid and decrease in pH which resulted from shaking 25 ml. of milk in 75 ml. test tubes. The tubes were shaken violently in a motor-driven machine which was placed in a room of constant temperature.

Table 1 shows that samples of raw milk from different cows decreased an average of 0.30 pH when shaken for 2 hours at 37° C.; whereas pasteurized aliquots shaken, raw milk held for 2 hours at 37° C. without shaking, or held over night at 5° C., showed no change in pH.

TABLE 1

Effect of 2 hours' shaking at 37° C. on the pH of raw and pasteurized whole milk

Sample number	Fresh raw pH	Over night at 5° C. raw pH	2 hours at 37° C.			
			Raw held unshaken pH	Shaken 2 hours		
				Past. pH	Raw pH	Dif. pH
1	6.52	6.53	6.50	6.52	6.22	0.30
2	6.64	6.66	6.64	6.66	6.41	0.25
3	6.63	6.66	6.62	6.63	6.35	0.28
4	6.53	6.55	6.48	6.55	6.16	0.39
5	6.55	6.56	6.54	6.55	6.27	0.28
6	6.62	6.63	6.60	6.62	6.28	0.34
7	6.61	6.52	6.42	6.52	6.22	0.30
8	6.65	6.56	6.51	6.60	6.23	0.37
9	6.49	6.52	6.50	6.49	6.35	0.14
10	6.56	6.60	6.57	6.57	6.22	0.35
Average	6.58	6.58	6.54	6.57	6.27	0.30

Experiments of a similar type in which the milk was shaken for 2 hours at 25° C. with and without the addition of ethyl butyrate are presented in Table 2. The first group of samples were from cows in the middle of the lactation period, the second group from cows at the end of the lactation period. The experiments were run during November and December of 1935. The samples from the group of cows in the more advanced period of lactation did not show greater lipolytic activity as a result of shaking. The increase in acidity as a result of shaking was slightly greater in the presence of ethyl butyrate, which was added originally because it usually prevents churning. The increases in titratable acidity parallel the decreases in pH. The acidity increased less with shaking at 25° C. than at 37° C.

TABLE 2

Effect of 2 hours' shaking at 25° C. on the increase in acidity of raw and pasteurized milk
Sample Nos. 1 to 10 from cows relatively high in milk production
Sample Nos. 11 to 20 from cows relatively low in milk production

Sample number	pH						Acidity as % lactic acid					
	Natural whole milk			Natural whole milk + 2% ethyl but.			Natural whole milk			Natural whole milk + 2% ethyl but.		
	Raw	Past.	Dif.	Raw	Past.	Dif.	Raw	Past.	Dif.	Raw	Past.	Dif.
	pH	*pH*	*pH*	*pH*	*pH*	*pH*	%	%	%	%	%	%
1	6.25	6.54	0.29	6.18	6.57	0.39	.227	.170	.057	.245	.166	.079
2	6.29	6.54	0.25	6.17	6.54	0.37	.220	.175	.045	.230	.175	.055
3	6.28	6.47	0.19	6.21	6.45	0.24	.225	.185	.040	.235	.187	.048
4	6.40	6.64	0.24	6.22	6.62	0.40	.172	.120	.052	.202	.125	.077
5	6.21	6.62	0.41	6.13	6.61	0.48	.260	.160	.100	.270	.155	.115
6	6.20	6.49	0.29	6.11	6.49	0.38	.262	.185	.077	.292	.187	.105
7	6.32	6.43	0.11	6.26	6.43	0.17	.217	.190	.027	.222	.190	.032
8	6.26	6.53	0.27	6.08	6.49	0.41	.235	.175	.060	.265	.180	.085
9	6.25	6.41	0.16	5.99	6.40	0.41	.225	.197	.028	.250	.195	.055
10	6.37	6.53	0.16	6.20	6.53	0.33	.220	.175	.045	.240	.175	.065
Average	6.28	6.52	0.24	6.16	6.51	0.36	.226	.173	.053	.245	.174	.071
11	6.32	6.62	0.30	6.28	6.58	0.30	.190	.132	.058	.195	.137	.058
12	6.47	6.66	0.19	6.40	6.65	0.25	.195	.155	.040	.205	.155	.050
13	6.33	6.65	0.32	6.26	6.64	0.38	.185	.125	.060	.200	.130	.070
14	6.45	6.82	0.37	6.40	6.82	0.42	.180	.110	.070	.190	.110	.080
15	6.62	6.80	0.18	6.60	6.80	0.20	.175	.130	.045	.175	.130	.045
16	6.36	6.63	0.27	6.26	6.63	0.37	.200	.125	.075	.227	.125	.102
17	6.51	6.68	0.17	6.56	6.72	0.16	.180	.137	.043	.180	.137	.043
18	6.38	6.67	0.29	6.31	6.67	0.36	.197	.130	.067	.210	.132	.078
19	6.58	6.81	0.23	6.58	6.82	0.24	.157	.117	.040	.160	.120	.040
20	6.29	6.52	0.23	6.26	6.50	0.24	.225	.165	.060	.240	.170	.070
Average	6.43	6.68	0.25	6.39	6.68	0.29	.188	.133	.055	.198	.134	.064

Table 3 shows that the acidity increases with time of shaking, the greatest increase occurring in the first two hours. After a preliminary shaking at 25° C., the acidity continues to increase even when the milk is held afterward at 2° C. The relative increases are much the same when 2 per cent tributyrin is added, but the actual increases in acidity are greater, and the unshaken samples containing tributyrin show a marked increase in acidity on holding. Table 3 shows that milk which normally shows no lipolytic activity is capable of activation to produce definite lipolysis.

Temperature is a controlling factor in lipolytic activation of milk by shaking. If the milk is held and shaken at low temperatures the lipase is not activated. Table 4 shows a comparison of milk shaken at 2° and at 25° C. Definite lipolysis of natural fat occurred in the case of only one sample which was shaken and held at 2° C. This sample was undoubtedly one of those in which the lipase was naturally active. Since shaking is not

TABLE 3

Effect of time of shaking at 25° C. and time of subsequent holding at 2° C. on the increase in titratable acidity and decrease in pH of raw milk

Time of holding at 2° C. after shaking, hours	Control	Natural raw whole milk						Raw whole milk + 2% tributyrin					
		Hours of shaking at 25° C. prior to holding at 2° C.						Hours of shaking at 25° C. prior to holding at 2° C.					
		0	½	1	2	3	4	0	½	1	2	3	4
		Increase in titratable acidity, per cent											
0	.001	.005	.013	.022	.038	.049	.055	.017	.037	.041	.078	.097	.106
24	.001	.018	.042	.049	.069	.067	.085	.063	.132	.126	.147	.154	.161
48	.001	.029	.059	.069	.084	.089	.094	.105	.174	.171	.189	.175	.187
72	.005	.041	.075	.082	.092	.102	.109	.125	.204	.206	.222	.209	.219
		Decrease in pH											
0	.02	.00	.07	.10	.16	.17	.21	.14	.42	.42	.57	.61	.67
24	.07	.06	.19	.20	.29	.30	.32	.43	.71	.67	.77	.75	.77
48	.05	.11	.23	.26	.32	.32	.36	.56	.78	.84	.86	.87	.88
72	.03	.19	.27	.32	.35	.41	.41	.63	.88	.87	.96	.93	.93

necessary to induce the hydrolysis by raw milk of simple esters such as tributyrin and ethyl butyrate, the samples to which the esters were added and which were shaken and held at 2° C. showed appreciable hydrolysis when held for 24 hours.

Most of the experiments on lipolysis due to shaking, previously reported in the literature, had been performed with human milk. Table 5 shows that little lipolysis of human milk occurs as a result of shaking at a low

TABLE 4

Effect of holding for 24 hours at 2° C. on the increase in titratable acidity after shaking for 2 hours at 25° and 2° C. Milk from cows late in lactation

	Cow number				
	1	2	3	4	5
Direct titratable chloride value, per cent	.137	.129	.178	.143	.152
Titratable acidity, unshaken sample, per cent	.175	.160	.092	.165	.140
pH	6.59	6.52	6.86	6.52	6.64
	Increase in titratable acidity				
Natural raw milk shaken 2 hrs. at 25° C.	.055	.030	.035	.047	.047
Shaken 2 hrs. at 25° C. and held 24 hrs. at 2° C.	.090	.058	.052	.072	.078
Raw milk + 2% ethyl butyrate shaken 2 hrs. at 25° C.	.055	.060	.040	.053	.063
Shaken 2 hrs. at 25° C. and held 24 hrs. at 2° C.	.113	.110	.070	.105	.125
Natural raw milk shaken 2 hrs. at 2° C.	.000	.000	.010	.002	.022
Shaken 2 hrs. at 2° C. and held 24 hrs. at 2° C.	.000	.018	.007	.010	.038
Raw milk + 2% ethyl butyrate shaken 2 hrs. at 2° C.	.020	.015	.015	.010	.020
Shaken 2 hrs. at 2° C. and held 24 hrs. at 2° C.	.100	.105	.050	.080	.085

pH determinations were also made. They confirm the results of the titratable acidity values.

TABLE 5

Effect of temperature of shaking on the lipolysis of human milk as indicated by the increase in titratable acidity expressed as lactic acid

Time of experiment, 1 hour	Temperature	
	5–6° C.	25–28° C.
	Titratable acidity per cent	
Unshaken	.023	.023
Shaken	.027	.108
Shaken	.032	.108

temperature, as contrasted with shaking at 25° C. These results confirm previous investigations indicating that lipolysis of human milk is stimulated to a greater extent by shaking than is lipolysis of cow's milk.

Anderson (1) and Mattick and Kay (16) used tributyrin as a substrate for studying the lipolytic activity of cow's milk. Experiments indicate that shaking is not necessary to induce hydrolysis of simple esters. The fact that no activation is necessary to cause the hydrolysis of simple esters, whereas activation is necessary to induce the true lipolysis of the natural fat, serves to differentiate the two reactions. The hydrolysis caused by

TABLE 6

Effect of the combination of ethyl butyrate and tributyrin on the increase in titratable acidity and decrease in pH. Shaken (2 hours at 25° C.) and unshaken milk after holding at 2° C. for 24 hours

	Increase in titratable acidity		Decrease in pH	
	Shaken %	Unshaken %	Shaken pH	Unshaken pH
	Sample No. 1 0.118% apparent titratable Cl			
Natural raw milk	.095	.005	.34	.00
Raw milk + 2% ethyl-n-butyrate	.142	.115	.64	.51
Raw milk + 2% tributyrin	.168	.127	.88	.67
Raw milk + 1% ethyl-n-butyrate + 1% tributyrin	.142	.122	.75	.64
Raw milk + 2% ethyl-n-butyrate + 2% tributyrin	.155	.137	.81	.73
	Sample No. 2 0.178% apparent titratable Cl			
Natural raw milk	.050	.007	.32	.05
Raw milk + 2% ethyl-n-butyrate	.065	.067	.36	.36
Raw milk + 2% tributyrin	.100	.070	.62	.49
Raw milk + 1% ethyl-n-butyrate + 1% tributyrin	.095	.073	.67	.54
Raw milk + 2% ethyl-n-butyrate + 2% tributyrin	.095	.075	.67	.54

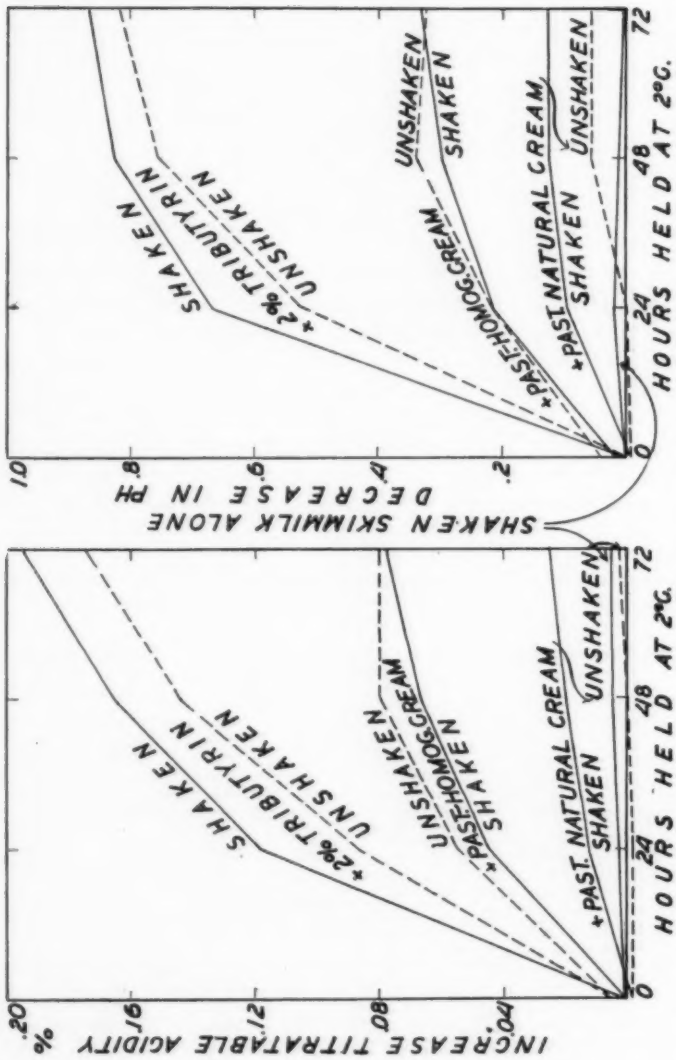

FIG. 1. Effect on lipolytic activity of reconstituting shaken and unshaken skimmilk with homogenized and natural cream and the addition of tributyrin.

shaking milk to which the simple esters were added was greater than that of the milk when shaken alone, but the increase in acidity was not the sum of the two processes operating alone. Table 6 presents further evidence that the increases in acidity produced by shaking milk alone and when both tributyrin and ethyl butyrate are present is not additive. The increase in acidity seems to approach a limiting value, indicating the establishment of an equilibrium or the retardation of the action of the enzyme due to the low pH.

As indicated in Figure 1, little subsequent effect of the shaking was found when 2% tributyrin, 4% homogenized cream, or 4% natural cream was added to shaken and unshaken skimmilk. Marked lipolysis occurred when pasteurized homogenized cream was added to raw skimmilk, but not when pasteurized natural cream was added.

No important influence of breed on the increase in acidity as a result of shaking was found, as shown by Table 7, although the milk from Jersey

TABLE 7

Effect of breed on the increase in acidity produced by shaking for 2 hours at 25° C.

	Decrease in pH		Increase in titratable acidity	
	Natural milk	Natural milk + 2% ethyl butyrate	Natural milk	Natural milk + 2% ethyl butyrate
	pH	*pH*	%	%
Holstein	.23	.31	.049	.059
Jersey	.25	.31	.067	.076
Guernsey	.23	.33	.048	.061
Ayrshire	.23	.30	.052	.064
Average	.24	.31	.054	.065

cows showed slightly greater increases in acidity.

A definite relation exists between the increase in titratable acidity and the decrease in pH, as shown in Figure 2, but since with the same increase in titratable acidity different alterations in pH would occur because of the difference in the buffer value of the milk, the increase in titratable acidity would be more directly related to the lipase activity.

The increase in titratable acidity as a result of shaking the natural milk for 2 hours at 25° C., although less, is in general linearly related to the increase if ethyl butyrate or tributyrin is added, as shown in Figure 3.

No relation between the amount of milk produced per day and the increase in titratable acidity resulting from shaking is shown in Figure 4.

The milk from a large number of cows was tested to see if the lipase was naturally active. The milk was cooled at once and held cold for 2 days.

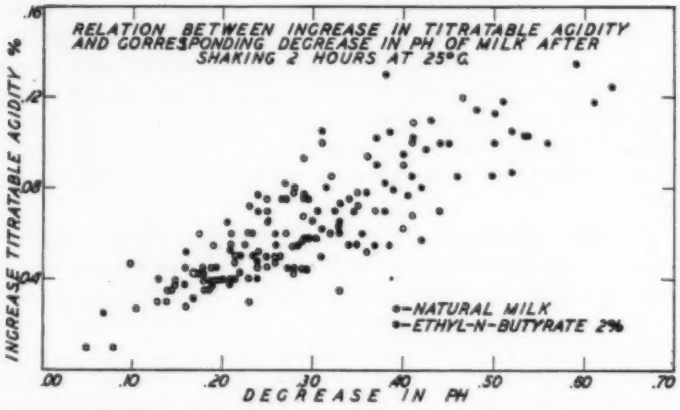

FIG. 2. Relation between the increase in titratable acidity expressed as lactic acid and the decrease in pH as a result of shaking.

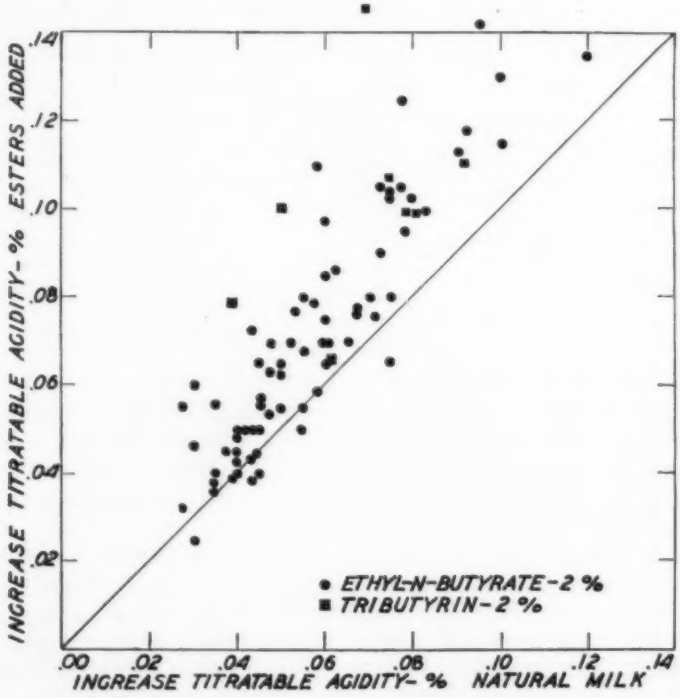

FIG. 3. Effect of the addition of esters on the increase in titratable acidity produced by shaking milk for 2 hours at 25° C.

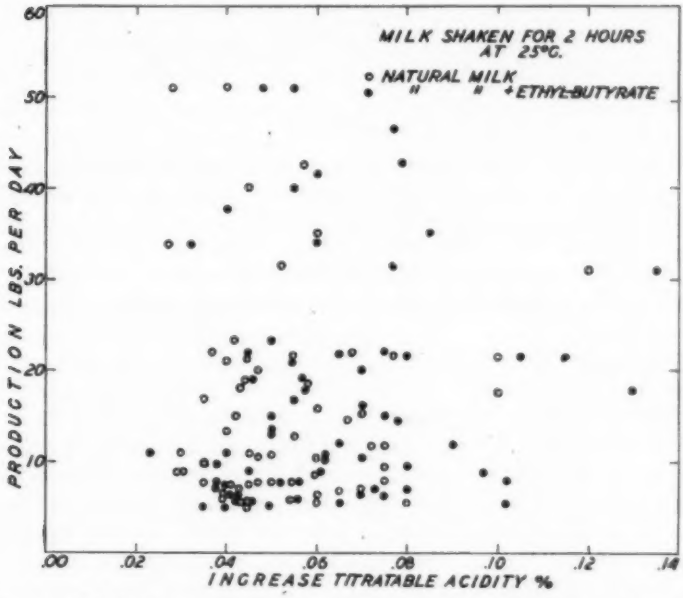

FIG. 4. Relation between the production of milk in pounds per day and the increase in titratable acidity produced by shaking.

An increase in titratable acidity on holding was taken as an indication that the lipase was naturally active. The milk from a large number of cows in advanced lactation in the summer was tested, but none showed an increase in titratable acidity. A few cows in advanced lactation in winter

TABLE 8

Milk obtained in the winter which showed natural lypolytic activity

Cow No.	Increase in titratable acidity as a result of		Direct titratable chloride value	Month of lactation	Milk per day
	Holding unshaken at 2° C. for 48 hrs.	Shaking 2 hrs. at 25° C.			
	%	%	%		*lbs.*
1 Jersey	0.020	0.053	0.09	10	7.7
2 Jersey	0.024	0.055	0.12	11	7.0
3 Holstein	0.028	0.025	0.15	11	9.0
4 Holstein	0.055	0.055	0.15	12	2.2
5 Holstein	0.038*	0.047	0.15	....	10.6

* Held cold 24 hours.

gave milk in which the acidity increased on holding. The data are presented in Table 8. Although this milk was naturally lipolytically active, it showed about the same lipolyis as a result of shaking as did average normal milk.

DISCUSSION

Shaking raw milk while the fat is in the liquid or partially liquefied state activates the lipase naturally present. Hydrolysis of the fat is indicated by the increase in titratable acidity, decrease in pH, and the characteristic odor and taste of the milk. Although shaking apparently gives no indication as to whether the lipase is naturally active in the milk, it does afford a simple method of demonstrating quickly the lipolytic potentialities of the milk.

Dorner and Widmer (6) found that the lipase of raw milk could be activated by homogenization. This fact has been confirmed by others (20), and Gould and Trout (12) showed that tremendous increases in the acidity of the fat occurred. Van Dam (21) has shown that the degree of dispersion of the fat is increased by shaking milk while the fat is in the liquid state. We have confirmed this observation. Thus activation of lipase by homogenization and by shaking may be basically the same. Whether an increase in degree of dispersion is necessary in order to activate the lipase of the milk by shaking, or whether the activating mechanism is an alteration in the surface characteristics of the fat globules, is not clearly demonstrated by the shaking experiments alone. The alteration in the surface characteristics is believed to be the activating factor, the increase in the degree of dispersion being largely incidental. This belief is strengthened by the known influence of temperature of separation on the lipolytic activity of cream (20). Cream from milk, warmed and separated while the fat is in the liquid state, shows little lipolytic activity as contrasted to cream separated while the fat is in the solid or partially solid state. Both creams show about the same amount of lipolytic activity when subsequently activated by homogenization. This indicates that lipase is actually present in both creams, but because of the previous temperature history of the fat and its physical state, in one case the lipase is active, in the other not.

Lundstedt (15) claimed that whipping cold milk lowered the curd tension of the milk. He attributed this lowering of the curd tension to materials removed from the surface of the fat globules as a result of the agitation. In our experiments, shaking cold raw milk did not induce lipolysis of cow's milk nor of human milk.

Under certain conditions raw milk from some cows in advanced lactation naturally shows lipolysis when held cold for a day or two. It is but natural to draw the conclusion that such milk contains more lipase than does other more normal milk which does not increase in acidity under the same conditions. However, when both types of milk are subjected to

special activating treatments such as to shaking or homogenization, they both show about the same amount of lipolytic activity. These results point to the conclusion that, although the amount of lipase as evidenced by shaking may vary considerably, yet all milk contains enough lipase which if activated would produce rancid milk, but only in the case of certain cows, usually in advanced lactation, is the condition of the milk such that when cooled at once the lipase is in a naturally activated state. We use the term activation in a broad sense to include the possibility that the apparent activation may be due to the prevention of the action of an inactivator.

CONCLUSIONS

1. Shaking of raw, whole cow's milk, while the fat is in the liquid or partially liquefied state, induces lipolysis.

2. Lipolysis induced by shaking will continue after the milk has been cooled to low temperatures.

3. The amount of lipolysis induced by shaking bears little or no relation to breed, season, or milk production of the cow.

4. The effect of shaking is attributed to an alteration in the surface characteristics of the fat globules which creates a condition more favorable for lipolysis.

5. Apparently all milk is capable of appreciable true lipolytic activity if subjected to suitable activating treatments, but only from some cows, particularly those in advanced lactation in winter, is milk secreted which when cooled and held will show natural lipolytic activity.

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VOLUME CHANGES OF FAT IN COOLED CREAM HELD AT CONSTANT TEMPERATURE

A. H. RISHOI AND PAUL F. SHARP
Department of Dairy Industry, Cornell University, Ithaca, New York

INTRODUCTION

The increase in the specific gravity of milk when held cold at a constant temperature has been observed by Schröder (4), Toyonaga (6), and many others (2). Toyonaga explained the increase as due to the solidification of the fat. Attention has recently been called to the influence of the physical state of the fat on the specific gravity determination (5). The evidence is clear that a shrinkage in volume occurs at constant temperature when milk or cream is cooled quickly and held at temperatures which induce fat crystallization. Because of the much greater lag in phase change of fat globules, the time required for fat in mass to crystallize gives little information as to the time required for fat globules in milk or cream to crystallize. A study of the change in physical state of the fat as indicated by specific heat determinations indicated that about 4 hours were required for the physical state to approximate the equilibrium value (3). In the present study, dilatometers were used to follow the change in physical state of the fat at constant temperature.

The dilatometer has previously been used principally to measure the expansion of the fat in cream, on warming after having been subjected to different degrees of cooling. Van Dam (8, 9) found that the maximum expansion occurred between 12 and 18° C. Hansen and Jensen (1) also showed that the more the cream was cooled the greater the expansion of the fat on warming.

EXPERIMENTAL

The construction of the dilatometer used is illustrated in Figure 1. The bore of the stopcock was large enough to permit the insertion of a drawn out glass tube through which the cream was introduced. This permitted the escape of the air and the complete filling of the bulb. The bulbs held 35 to 40 ml. The distance between the level of the mercury in the side arm capillary and a reference mark on the capillary was determined by means of a cathetometer. The diameter of the capillary side arm was previously determined by measuring the length of a mercury thread and weighing the mercury. From the movement of the mercury due to contraction of the fat, the contraction in volume per 100 grams of fat was calculated.

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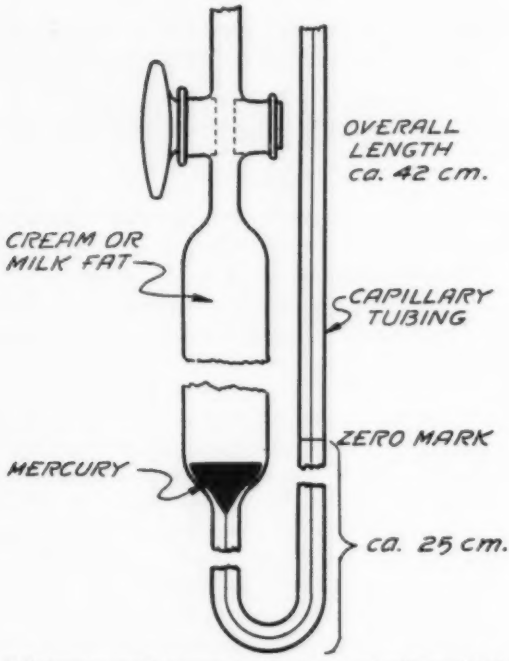

FIG. 1. Dilatometer used to measure the change of volume of fat in cream.

Several hours before beginning the experiment, the weighed dilatometers were placed in water baths maintained at the desired temperature by being held in thermostatically controlled air ovens which in turn were placed in refrigerated rooms. Cream from mixed milk was heated to 80° C. for 10 minutes, and cooled to 40° C., when 0.5 per cent of mercuric chloride was added (7). The cream was then filtered through cotton and stored at near freezing. Before being placed in the dilatometer the cream was warmed to 45° C. to melt the fat in the globules. It was then cooled to the temperature of the water bath, and the dilatometer was filled.

The dilatometers were held for five months at constant temperatures ranging from 0 to 20° C. The contraction in cc. per 100 grams of fat during the first 48 hours is plotted in Figure 2. The decrease in volume of the fat occurred rapidly at 0, 5, and 10° C. after adjusting the cream to the temperature of the bath; the contraction took place more slowly at 15° C. and very slowly at 20° C. Some contraction occurred at the lower temperatures before the cream could be cooled, adjusted to the temperature of the bath, the tonometer filled and the first reading taken. Therefore the data presented in Figure 2 should not be taken as an accurate indication

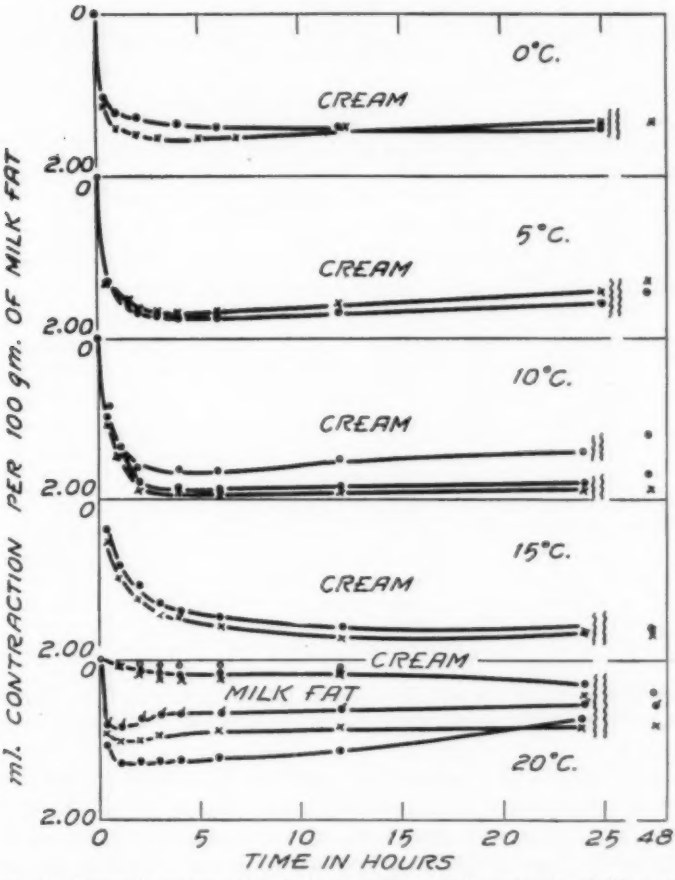

FIG. 2. Change in volume of milk fat in cream and in mass when held at constant temperature. Calculated on the basis of cc. change in volume per 100 grams of fat.

of the total contraction which occurred at the lower temperatures. The curves indicate the rate of contraction as influenced by temperature. At temperatures below 10° C., after the very rapid decrease in volume a slow increase in volume occurred. The increase occurred over a period of months, as is shown more clearly in Table I. At the present time the explanation for this slow expansion is not clear, but it is probably due to some slow phase adjustment following the relatively rapid original crystallization of the fat. The secondary expansion was not observed in cream held at 15 and 20° C., but it was observed in pure fat held at 20° C. The decrease in volume of the fat in cream held at 25° C. occurred so slowly

TABLE I

Decrease in volume of fat on holding cream and pure milk fat for various periods of time at constant temperature

Temperature of holding	cc. decrease in volume per 100 grams of milk fat after							
	30 min.	1 hour	4 hrs.	1 day	1 week	1 mo.	2 mo.	5 mo.
° C.				40% fat cream				
0	1.01	1.23	1.36	1.38	1.30	1.08	0.95	.....
	1.14	1.41	1.55	1.39	1.28	1.15	1.16	1.12
5	1.32	1.48	1.75	1.60	1.20	1.09	1.12	1.25
	1.30	1.46	1.71	1.49	1.12	.92	.81	.99
10	1.05	1.46	1.84	1.81	1.69	1.68	1.68	1.57
	1.08	1.48	1.90	1.92	1.92	1.94	1.92	2.07
	0.89	1.31	1.60	1.38	1.13	1.24	1.37	1.76
15	0.41	0.82	1.35	1.54	1.65	1.71	1.67	1.97
	0.52	0.98	1.49	1.68	1.72	1.71	1.75	2.29
	0.37	0.84	1.34	1.54	1.68	1.78	1.87	2.35
20	0.00	0.06	0.19	0.28	0.29	0.40	0.59	1.52
	0.00	0.12	0.27	0.40	0.44	0.54	0.81	1.34
	0.00	0.03	0.17	0.29	0.32	0.40	0.76	1.33
				Pure milk fat				
20	0.96	1.05	0.85	0.77	0.77	0.74	0.68	0.80
	0.85	0.80	0.67	0.63	0.59	.....	0.41	0.31
	1.03	1.30	1.27	0.70	0.60	.....	0.48	0.39

that dilatometers were not held at this temperature. The changes in volume of the fat in cream held for the longer periods of time are given in Table I.

Table I shows that it may require weeks or months for the fat to attain a state of equilibrium when held at constant temperatures of 20° C. or below. This table emphasizes again the unsuitability of temperatures at which the fat may be in the crystalline state, for obtaining the specific gravity values which are used for the calculation of total solids (5).

Although Figure 2 and the specific heat values previously reported (3) indicate that within 4 hours phase adjustment of the fat approaches a relatively stable state, yet Table I shows that superimposed on this apparently stable state is a secondary adjustment which may require months. In Table I the data for 10° C. are not consistent. This temperature is probably near the point at which the two behaviors are occurring simultaneously at near the same rate, that is, the primary crystallization which causes a decrease in volume and the secondary adjustment of phases which results in an increase in volume.

Observations on surface tension, creaming, cream viscosity, lipase action, foaming, etc., indicate that it is the adjustment of the surface condi-

tions of the fat globules, as produced by the crystallization which occurs in the first few hours, which is most important in controlling the behavior of milk products.

CONCLUSIONS

1. At 0, 5, and 10° C. the maximum contraction of the fat in cooled cream occurs in about 4 hours. At 15 and 20° C. contraction of the fat may take place over a period of months.

2. At 0 and 5° C. after the maximum contraction of the fat in cream, a slow expansion occurs for two months or more. This second stage of expansion is probably a phase adjustment following the initial rapid crystallization of the fat.

3. The adjustment of the physical state of the fat globules which at low temperature approaches completion in about 4 hours, is the important change which alters the surface properties and adsorption on the fat globules, and influences such properties as cream viscosity, creaming, surface tension, foaming, l' ase, etc.

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STUDIES ON THE COMPOSITION OF BOVINE BLOOD

I. THE MAGNESIUM CONTENT OF THE BLOOD PLASMA OF THE NORMAL DAIRY CALF*

C. W. DUNCAN, C. C. LIGHTFOOT AND C. F. HUFFMAN

From the Chemistry Section and Section of Dairy Husbandry of the Michigan Agricultural Experiment Station, East Lansing

A study of some of the constituents in the blood of dairy cattle was undertaken as a phase of a more comprehensive investigation of the problem of requirements and metabolism of certain elements by dairy cattle in relation to the occurrence of deficiency diseases and with special reference to the use of home-grown feeds for economical milk production. During the past few years our attention has been directed towards a study of the magnesium requirements of cattle (1–4). In extending this investigation it was found desirable to determine the concentration and normal variations of this element in the blood plasma of growing calves over long periods of time since a review of the available literature on the magnesium content of calf blood indicated a general lack of agreement concerning the normal concentration in the blood of calves at various ages. A systematic study, therefore, has been made in which the magnesium, calcium, inorganic phosphorus, chloride and carbon dioxide content has been repeatedly determined from birth to 18 months of age with special reference to the influence of growth and environment under normal conditions of calf management.

Theiler, Green and du Toit (5) reported a value of 6.5 mg. of magnesium per 100 cc. of whole blood for a calf 24 hours after birth. Green and Macaskill (6) found that the concentration of magnesium in the whole blood of a cow and calf was higher than in the plasma and that about two-thirds of the magnesium was in the corpuscles and one-third in the plasma. Normal magnesium values of young calves were found to vary from 2.25 to 2.75 mg. per cent according to Sjollema (7) but the values for calves from 9 to 10 months of age were given as 1.6 to 1.8 mg. per cent. Přibyl (8) found that the serum magnesium varied from 1.21 to 2.24 mg. (average 1.97 mg.) in four suckling calves and that these values were within the same range as their dams.

Allcroft and Godden (9) reported that the serum magnesium values of calves at birth were definitely lower than the normal value for the dam and remained so for the first two weeks. Their mean value obtained from 55 determinations on calves from birth to 28 days of age was 1.79 mg. per 100 cc. (range 1.12–2.25 mg.), whereas the mean value obtained from 32 de-

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terminations during the second month of life was 1.97 mg. (range 1.47–2.50 mg.). Groenewald (10) concluded from a series of determinations that the mean magnesium value was 3.09 mg. per 100 cc. of blood plasma for calves from 1 to 85 days of age (range 2.3–4.2 mg.). He also observed that the magnesium content of calf blood was slightly higher than that of cows' blood and that there was no decline of this element in calves' blood during the first three months of life. Malý (11) reported that the blood magnesium of suckling calves ranged from 1.29 to 2.24 mg. (average 1.72 mg.). We (1) have previously indicated that normal plasma magnesium values varied from 2.25 to 2.75 mg. for calves from birth to 300 days of age. Under the conditions of the experiments reported by Herman (12), the average normal serum magnesium value of calves from 8 to 369 days of age was 3.23 mg., with variations from 2.53 to 4.72 mg.

The present paper is the first report of a series of investigations concerning the normal concentrations, variations, and relationships of certain constituents in the blood of growing and mature dairy animals, in health and disease, and deals specifically with plasma magnesium.

METHODS

Several important considerations governed the routine of this experiment. An effort was made to obtain comparable samples of blood from calves which were representative of normal practice in calf management. The blood was always withdrawn in the morning about one hour prior to the regular feeding time so the influence of food was a negligible factor. A uniform procedure was also adopted for the withdrawal of the blood and its disposition after being received in the laboratory. In no instance was the blood allowed to stand at room temperature for any length of time. The routine analytical procedure for the determination of plasma magnesium has been previously reported (1). In nearly all cases it was possible to check the results by a duplicate determination and such checks were invariably within reasonable agreement ($\pm$ 5 per cent or less of the magnesium determined). The significance of the results is further enhanced by the fact that one person (C. C. L.) was responsible for all of the determinations.

Samples of blood from 107 calves (86 Holsteins, 14 Jerseys, 4 Guernseys, and 3 Brown-Swiss, of which 47 were males and 60 were females) were obtained every week or every two weeks. In a few cases less than 10 samples of blood were obtained but in other cases it was possible to obtain the samples during the entire period. The average number of samples from each calf was 21.

Rations—The calves used in this investigation received whole milk twice a day from birth to 60–90 days of age in amounts according to the needs of each calf, after which time they were changed to a ration of skim

milk. The skim milk was discontinued at 5–6 months of age. A mixture of corn and oats, equal parts by weight, was fed as soon as the calves would eat it and alfalfa hay (U. S. No. 2) was also fed ad lib. from the same time. Corn silage was fed after the calves were 4 months of age. Water was offered twice a day until they were placed in stanchions at about 1 year of age after which they were watered by individual water bowls. The heifers were turned outside during the day for exercise except during inclement weather. They were also pastured on June grass or alfalfa pasture during the pasturing season after they were 10 months of age.

The protein content of the alfalfa hay averaged 15 per cent whereas the phosphorus content was less than 0.2 per cent.

RESULTS

The statistical evaluation of the results are recorded in Table 1, supplemented by a histogram (Fig. 1) and a graph (Fig. 2). The data

TABLE 1.

Effect of age on plasma magnesium

Age	Determinations	Mean	Min.	Max.	S.D.	P.E.	C. of V.
mo.	no.	milligrams per 100 cc. of plasma					per cent
0.5	163	2.389 ± 0.015	1.78	3.14	0.287	0.194	12.01
1.5	259	2.345 ± 0.014	1.64	3.33	0.334	0.225	14.24
2.5	260	2.345 ± 0.015	1.62	3.33	0.360	0.243	15.35
3.5	244	2.322 ± 0.014	1.66	3.27	0.323	0.218	13.90
4.5	230	2.407 ± 0.015	1.67	3.36	0.341	0.230	14.16
5.5	173	2.415 ± 0.020	1.78	3.67	0.385	0.260	15.94
6.5	115	2.429 ± 0.025	1.74	3.65	0.390	0.263	16.06
7.5	112	2.441 ± 0.023	1.66	3.43	0.365	0.246	14.95
8.5	93	2.471 ± 0.028	1.84	3.71	0.400	0.270	16.18
9.5	96	2.428 ± 0.030	1.84	3.75	0.431	0.291	17.75
10.5	98	2.535 ± 0.031	1.71	3.60	0.457	0.308	18.02
11.5	91	2.591 ± 0.032	1.87	3.65	0.449	0.303	17.32
12.5	72	2.589 ± 0.034	1.99	3.63	0.430	0.290	16.60
13.5	67	2.445 ± 0.038	1.83	3.67	0.461	0.311	18.85
14.5	59	2.470 ± 0.037	1.84	3.77	0.424	0.286	17.16
15.5	52	2.403 ± 0.035	1.84	3.83	0.369	0.249	15.35
16.5	51	2.431 ± 0.033	1.97	3.38	0.353	0.238	14.51
17.5	51	2.531 ± 0.036	1.86	3.72	0.384	0.259	15.16
Combined	2286	2.414 ± 0.005	1.62	3.83	0.378	0.255	15.65

presented in the table were derived from 2286 analyses of blood plasma from calves from birth to 18 months of age, and show the number of determinations made for each of the 18 months, the mean magnesium value and its probable error for each month expressed in terms of milligrams per 100 cc. of blood plasma, the minimum and maximum value for each month, the standard deviation, probable error, and the coefficient of variation for each of the periods under consideration.

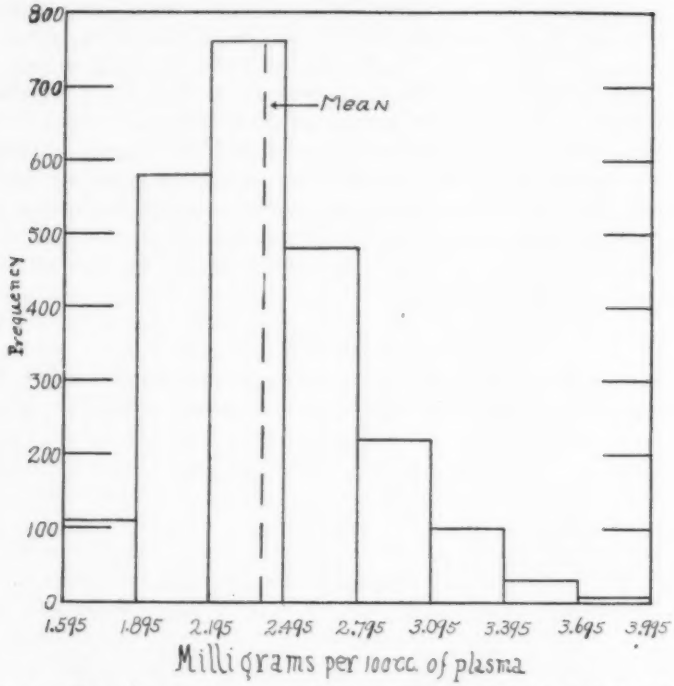

FIG. 1. Histogram showing grouped frequency distribution in variation of 2286 plasma magnesium values from 107 normal dairy calves.

In a frequency distribution table (unpublished basic data) from which the data in Table 1 were derived, the data were classified into 23 classes with an interval of 0.10 mg. between each class. By dividing the data into this number of classes a fairly uniform distribution was obtained. The

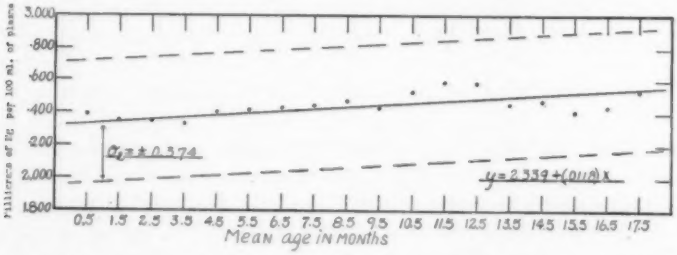

FIG. 2. Dots represent the observed mean plasma magnesium values of normal calves from birth to 18 months of age and the straight line obtained from the experimental data by the method of least squares.

histogram (Fig. 1) was constructed by grouping the data in the frequency distribution table into class intervals of 0.30 mg.

DISCUSSION

From an analysis of the results obtained by the repeated determinations of magnesium in the blood plasma of growing calves, it is evident that both the absolute and relative amounts of this element were subject to considerable variation. It will be seen at once that the mean values obtained are at some variance with those recorded in the literature. Our mean values are definitely higher than some that have been reported (7, 8, 9, 11) and definitely lower than others (5, 10, 12). The significance that may be attached to any series of determinations of magnesium in the blood depends largely upon the conditions under which the determinations were made. There are many factors which may affect the values obtained, including the method of analysis and the particular procedure employed in carrying out a given method. When all other conditions are uniform irregularities in handling the blood after it is drawn will give rise to surprisingly large differences in the values obtained. Permitting the blood to stand at room temperature or to be stored in a refrigerator for some length of time tends to increase the magnesium in the blood plasma. It is desirable to emphasize the fact that the results recorded above are to be viewed as results obtained under certain prescribed conditions which differ in many respects from those governing the determinations made by other investigators.

The values obtained for magnesium may be regarded as showing fairly close agreement for the ages under consideration. It is important to state, however, that all of the 47 male calves had been removed from the investigation by the time they were six months of age. The values recorded in Table 1 for the first six months represent the mean values obtained for both male and female calves. The data for each sex were statistically analyzed and no significant differences were noted for the period under consideration. Starting with the seventh month the mean values are for female calves only.

The extreme difference between the lowest and highest mean value (2.322 mg. for the 4th month and 2.591 mg. for the 12th month) is only 0.268 mg. or 11.1 per cent of the mean for the entire 2286 values. The limits of the probable variation from the trend line in Fig. 2 as determined by the standard error of prediction of the combined results are $\pm$ 0.374 mg. per 100 cc. of plasma, whereas the extreme limits of observation indicate an actual difference in the magnesium content of the plasma of normal calves of over 100 per cent.

Another important feature of these results is the array of the observed means about the predicting line. The prediction curve and the dots representing means (Fig. 2) show the goodness of fit of the means of the

observed values to the prediction curve derived by the method of least squares from the correlation table (unpublished). In a normal distribution 68.26 per cent of the experimental values will fall between $-1\ \sigma_e$* and $+1\ \sigma_e$, whereas under our experimental conditions, 72.5 per cent of the observed values actually occurred between $\pm 1\ \sigma_e$. On the basis of probability, the chances are 2.64 to 1 that any experimental value will be found within one standard error of prediction above or below the trend line. It is also interesting to note that Fig. 2 shows two types of variation. One of these is progressive in character and represents a gradual increase in the magnesium values from birth to 18 months of age. This gradual change in concentration is also accompanied by clearly defined series of rhythmic variations which extend over periods of several months. The first variation occurred during the first 4 months of life during which time there was a slight downward trend. This trend was reversed during the 5th month and the maximum value was established during the 12th month. During the next 6 months the direction was mixed but the mean values for the 17th and 18th months were definitely lower than the 12th and 13th months. The coefficients of variation were highest from the 10th to the 15th month, indicating, probably, a period of physiological disturbances. The figure indicates, however, that neither of these conditions represent a continuous movement in either direction and that high or low values were not maintained indefinitely.

The histogram (Fig. 1) shows fairly close agreement in the frequency with which values of a given magnitude occurred and the amount of asymmetry obtained from the distribution of all values. The coefficients of variation are comparatively large (12.01 to 18.85 per cent) but values between 1.895 and 2.795 mg. of magnesium per 100 cc. of plasma occurred with great frequency (79.7 per cent of all observations), while values below 1.895 and above 2.795 mg. were by no means rare. The extreme limits of observation indicate a potential difference in the magnesium content of the plasma of normal calves of over 100 per cent, whereas the limits of variation between 1.895 and 2.795 mg. indicate a difference of only 37.3 per cent of the mean for all months. This difference is large in absolute value and large in terms of percentage of the mean for all months. It is safe to assume, however, that the mean value obtained for each month indicates an actual difference in the concentration of magnesium in the blood from month to month.

Progressive changes in the chemical composition of the blood can, under certain conditions, be accounted for in various ways, but no satisfactory explanation can yet be offered for the factors which determine the level of magnesium or the factors which cause the periodic variations in the level of plasma magnesium in the growing bovine. The magnesium content of

* σ_e = Standard error of prediction.

the blood depends primarily upon the intake and utilization of magnesium, its storage and release from the tissues and skeleton and also upon the rate of growth.

SUMMARY AND CONCLUSIONS

Determinations of magnesium were made on the blood plasma of 107 normal dairy calves at intervals of 1 to 2 weeks over a period of 3 years. Values were calculated for the mean concentration of magnesium in the blood plasma for the first 18 months of life. The mean magnesium values showed fairly close agreement from month to month and a definite tendency to increase up to 12–13 months of age. The change in level was accompanied by a series of rhythmic variations which extended over several months. The mean value for all of the observed values was 2.414 mg. per 100 cc. of blood plasma (range 1.62–3.83 mg.) and 79.7 per cent of the values were between 1.895 and 2.795 mg. (Fig. 1), whereas 72.5 per cent of the values actually occurred within the limits established by the band of normality (Fig. 2).

The values for magnesium, as recorded above, may be regarded as a cross-section of results obtained from a fair sample of normal dairy calves and may be used as a standard of comparison in estimating the probable significance of other determinations. From the evidence obtained in these experiments, one must conclude that the mean values obtained for the concentration of magnesium in the blood of young dairy animals from month to month differ significantly from values obtained by other workers.

It has been shown that the concentration of magnesium can not be regarded as constant. The range of the so-called normal variation is in all probability sufficiently wide to include many variations that occur under pathological as well as physiological conditions since the maximum and minimum values for each month are definitely outside of the limits of the band of normality established for the combined values of the prediction curve. The results of this investigation also make it evident that fluctuations in the plasma magnesium content of the blood of growing dairy calves are to be expected as normal occurrences.

The authors wish to express their appreciation to Dr. W. D. Baten for his assistance with the statistical treatment of the data.

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FASTING ENERGY METABOLISM DURING LACTATION*

L. E. WASHBURN

Department of Dairy Husbandry, University of Missouri, Columbia

What is the energy requirement for physiologic maintenance[1] in the lactating dairy cow? Important as it is in the evaluation of energetic economy or efficiency of lactation, this question has not been answered satisfactorily in the pertinent literature. The common practice has been to substitute the so called basal metabolism[1] of a dry cow or a steer for the physiologic maintenance requirement of a lactating animal. Yet, it is well known that production of normal milk volume necessitates the feeding of twice to three times the energy required to maintain the dry animal, and that this extra energy intake is not wholly represented in milk energy yielded. We should like to know what part, if any, of this rather huge energy intake is actually necessary to change unit metabolizing tissue from the non-productive to the productive state, and what part is lost as heat increment of feeding. Graham Lusk (1) concluded that there was no difference in the basal energy production[1] in lactating and non-lactating women. But, it seems unbelievable that such can be true also for the dairy cow, an animal in which the persistency and quantity of milk production have been greatly enhanced through generations of selective breeding.

To determine the physiologic maintenance level an animal must be fasted until the specific dynamic effect of the previously ingested food reaches a minimum value. This requires about two days in the ruminant, and causes a decrease in milk yield. The question may therefore be raised as to whether a cow continues to lactate, in the true sense of the word, when subjected to such treatment. Some investigators, in fact, believe that a fasting animal is not a normally lactating animal because of the decline in milk yield. The dairyman on the other hand commonly considers lactation to continue as long as any milk is produced. However, lactation itself is believed to be a physiologic function, whereas milk yield is simply a result of lactation. If, as recent work suggests, lactation is regarded as an endocrine-stimulation of an energy-converting system between milk precur-

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[1] Physiologic maintenance is a term recommended by the Committee on Animal Nutrition, National Research Council, to refer to the energy necessary for maintenance of energy equilibrium under ideal conditions of environment. While physiologic maintenance and basal metabolism are synonomous in that both represent a level of energy production during fasting, the former is preferable for ruminants, since it is doubtful if these animals ever reach a post-absorptive state comparable with humans.

sors and milk constituents then we may reasonably believe that it may persist quite normally during fasting. The latter point of view appears justified for the following reasons: 1, The reduction or even cessation of milk flow by fasting or failure to remove formed milk have no apparent effect, within certain limits, upon the ability of the animal to again yield a normal quantity of milk after removal of the inhibition (2, 3,); 2, A falling milk yield is compensated in part at least by changes in the percentages of milk constituents. This is true particularly for milk fat, its position as primary, energy-yielding, milk constituent being increasingly emphasized during fasting.

This report presents preliminary data obtained from fasting energy metabolism studies with a lactating and a dry dairy cow, which were subjected to the same conditions of environment and treatment. The main objectives of these studies were, 1, to ascertain how the fasting heat production curves of the lactating and dry cow were related; and, 2, to find if a physiologic maintenance level could be measured during lactation. As a working basis, lactation was assumed to be an endocrine-stimulated energy-converting system, not necessarily measured by quantity of milk produced. It was further assumed that such an endocrine-stimulated activity may reasonably be placed in the category with other activities such as the circulatory, respiratory, heat regulating, and excretory mechanisms, which are usually considered quite resistant to such physiological stress as fasting.

EXPERIMENTAL

The fasting heat production of an eight year old Guernsey cow in the fourth month of lactation and an eight year old Jersey cow which had been dry for over a year was measured by an open circuit-mask respiration method which has been described previously (4). Energy metabolism was computed from the respiratory quotient[2] and volume of directly expired air obtained from the animals in a lying position, in respiration periods of 20–30 minutes duration. The respiration periods were started as soon as possible after consumption of the last feed, and were repeated about every two hours during the first 12 hours of fast and about every 3 to 5 hours thereafter. Corresponding periods for each animal were carried out at approximately the same time of day or night and interval after feeding.[3] Prior to fasting each animal was given feed of equal quality and quantity. Between respiration periods the animals were kept in adja-

[2] Total respiratory quotient, uncorrected for urinary nitrogen, but corrected for fermentation methane and carbon dioxide, determined by gas analysis with Haldane apparatus.

[3] Immediately after ending a period on one cow the other animal was started. About 5 minutes intervened between the periods of each animal to insure complete washing out of apparatus for gas sampling.

cent metabolism stalls (5), and were at all times subjected to the same manner of handling and environmental temperature (thermal neutrality). The lactating cow was milked regularly at 6 o'clock a.m. and p.m.

The resulting data are presented in Fig. 1 and Tables 1, 2, and 3.

TABLE 1

Average daily live weight, food and water consumption and excreta production during preliminary feeding periods

Animal	Live Weight	Hay[a]	Silage[b]	Grain[c]	Water	Milk	Feces	Urine
	Kgs.	Kgs.	Kgs.	Kgs.	Kgs.	Kgs.	Kgs.	Kgs.
#428								
Lactating	373.2	4.709	11.693 8.711*	3.178 1.589*	28.820	6.171	19.866	7.556
#831								
Dry	504.1	2.954	10.536 6.910*	3.178 1.589*	26.199	.....	18.289	8.657

[a] 5.0 Kgs. good quality alfalfa hay offered at p. m. feeding.
[b] 13.0 Kgs. silage offered at a. m. feeding.
[c] 1.589 Kgs. grain mixture offered at a. m. and p. m. feedings.
* Last feed before fast. Average for Experiments 2 and 3.

TABLE 2

Average milk and fat production during fasting
(Average for 3 trials)

Period	1	2	3	4	5	6
Hours fasting	12	24	36	48	60	72
Milk (Gms.)	2765	3111	2026	2006	1262	1612
Fat (Gms.)	134.9	153.1	135.0	136.8	98.4	137.0

DISCUSSION

While these data leave much to be desired, they point to some interesting aspects of energy metabolism in the dairy cow. Figure 1 shows that changes in fasting heat production are in general similar for both cows. In both animals the energy metabolism declines to about 47 per cent of the initial value within 48 hours after the last food is consumed. The absolute heat production (top chart) is about the same for a 750-pound lactating cow and a 1100-pound dry cow, each receiving the same kind of feed to the limit of appetite. Compared on a physiological weight basis (7), the heat production (middle chart) by the lactating cow is of the order of 20 per cent higher than that of the dry cow. This difference remains constant up to 60 hours fasting. Corrected further for gross energy intake (bottom chart), the energy production curve for the lactating cow is 10 per cent higher than that for the dry cow. Any attempt to interpret curve II (bottom chart) would be idle speculation with the data at hand. This curve may indicate that in the lactating cow, 1, an increasing rate of energy

TABLE 3

Average daily body weight loss, nitrogen excretion (milk and urine), and fecal output during fasting

Period of fasting	Weight loss Kgs. per 72 hrs.	Nitrogen excretion Gms. per 24 hrs.[a]	Fecal output		
			Kgs. dry matter per 24 hrs.[b]		
			Ballast[c]	Feces	Per cent loss
		#428 Lactating Cow			
First 12 hrs.		91.990	10.979	4.131	37.6
12–36 hrs.		87.439	6.848	2.603	38.0
36–60 hrs.		41.360	4.245	1.271	29.9
60–72 hrs.		71.972	2.974	0.502	16.9
Average	25.117	66.924 (12–72 hrs.)	.....	.....	.....
		#831 Dry Cow			
First 12 hrs.		129.122	8.507	3.605	42.4
12–36 hrs.		83.142	4.902	1.437	29.3
36–60 hrs.		66.509	3.465	0.342	9.9
60–72 hrs.		51.633	3.123	0.137	4.4
Average	26.346	67.095 (12–72 hrs.)	.....	.....	.....

[a] Uncorrected for specific gravity—assuming 1 gm. per cc. of urine or milk.

[b] Dry matter computed as follows: hay, 90%; grain, 90%; silage, 30%. Fecal dry matter assumed to be same for lactating and dry cow; about 20.1%. Also assuming that dry matter percentage remains fairly constant during fasting. See Benedict & Ritzman (6).

[c] Initial ballast assumed to be proportional to: *Daily dry matter intake – Daily dry matter of feces + Dry matter intake of last feeding.* Ballast for succeeding periods computed by subtracting fecal output from ballast in preceding period.

utilization occurs after 36 hours fast; or, 2, that heat increment per unit energy absorbed increases, possibly along with a declining demand for maintenance energy; or, 3, that body tissue becomes increasingly more important as a source for milk energy. In this connection it might be stated that loss in weight during fasting was apparently no greater for the lactating cow than for the dry cow. This is shown in Table 3 and further substantiated by the nitrogen excretion values in the same table.

A striking difference in the energy production of these cows is shown by the break in the curve for the lactating animal occurring after 60 hours of fast. The heat production level reached by both cows at 36–48 hours is maintained at least until 72 hours by the dry cow, but in the lactating cow it further declines about 20 per cent between 60 and 72 hours. This drop in total metabolism of the lactating cow at first thought seems fortuitous, but when considered in the light of other data presented herein it takes on significance. Table 3 shows that at 72 hours after food the lactating cow excreted feces at a rate about 400 per cent greater than the dry cow. Since these animals continued to excrete considerable quantities of methane,[4] even

[4] Methane excretion variable. Average value about 1.5 liters per hour between 36 and 72 hours fasting.

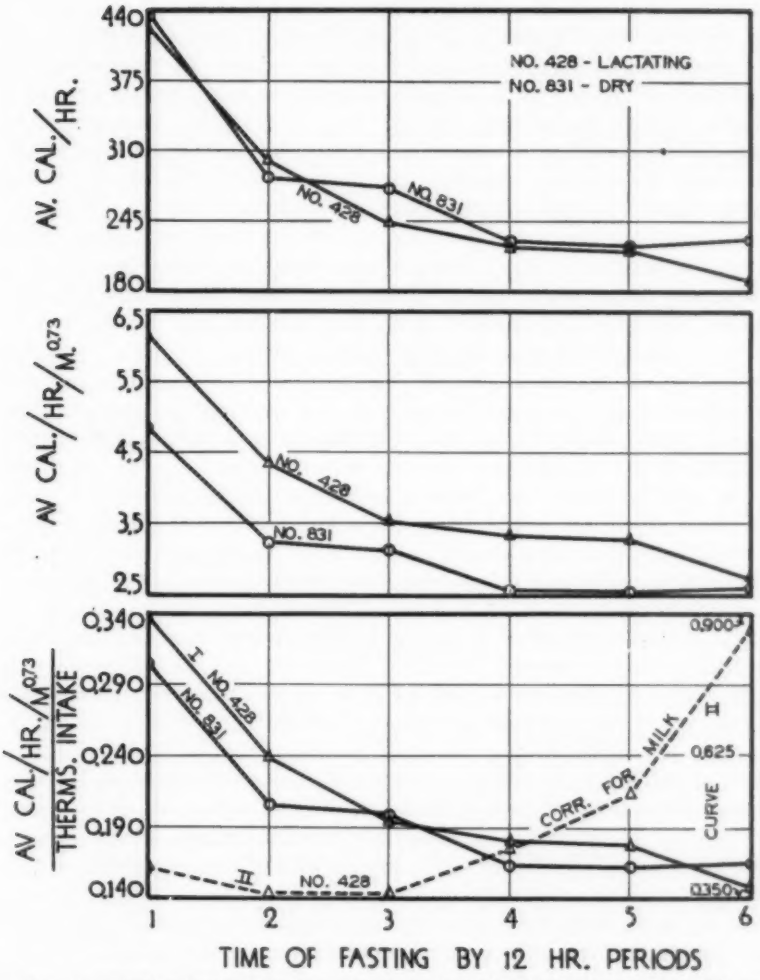

FIG. 1. Fasting heat production curves for lactating Guernsey cow No. 428 and dry Jersey cow No. 831. Top chart—total heat production (avg. for 2 fasting experiments). Middle chart—heat production per unit physiologic weight (0.73 power of live weight in kilograms). Bottom chart—values in middle chart further corrected for differences in energy intake (Therms). Curve II for cow No. 428 obtained by dividing values given in middle chart by gross energy intake minus milk energy (Therms).

at 72 hours, it appears that fermentative digestion and absorption were going on. Thus a certain part of the total heat production, even after a level had been attained, might have been due to heat increment of nutri-

ment absorbed from alimentary residue. The rapid rate of evacuation of the digestive tract by the lactating animal would then result in a decline in absorption and a drop in total heat production. In other words the lactating cow might have been approaching the so called hypothetical minimum energy production more quickly than the dry cow. Inasmuch as the hypothetical minimum metabolism of the ruminant has never been reported, we do not know how to apportion the total heat production during fasting between heat increment and the so called tissue metabolism.

It does not seem impossible that, under the strain of fasting, extramammary systems in the lactating animal might compensate by subsisting on a lower maintenance plane, so that mammary activity might be prolonged. Despite the common opinion that lactation stimulus elevates the level of energy metabolism of body tissue in general, no evidence has yet been advanced to show whether the increased total metabolism in lactation is due to elevated tissue metabolism or to increased heat increment of feeding. Apparently, increased food consumption is a factor in the higher metabolism of lactating cows stimulated by thyroxine (8, 9). It is well known that thyroxine stimulation in humans and other animals also results in greater food intake and tissue breakdown. Moreover, recent observations indicate that secretions of the pituitary (10, 11) and adrenal glands (12) act upon the alimentary system and are important factors in the absorption of nutriment.[5] Is it not justifiable then to assume that the endocrine stimulus of lactation acts in a large degree upon the alimentary system, making for greater nutriment absorption and hence a greater heat increment from nutriment? Of course it can be argued that greater food intake in lactation is caused by a greater demand of body tissue for energy. In this connection, however, one must remember that food intake is regulated essentially by appetite or hunger manifested by characteristic sensations and activity of the alimentary system, not by body tissue in general.

Another possible cause for the drop in total metabolism of the lactating cow might be the breakdown and disappearance of some metabolism stimulating mechanism associated with lactation. It is possible that at 60 hours the heat production of the lactating animal begins to approach that of the dry animal, finally reaching such a level upon complete cessation of milk secretion. The data in Table 2, however, do not seem to substantiate this reasoning, at least within the limit of 72 hours of fast. It appears that the fat synthesizing mechanism endured with remarkable constancy during the entire experimental period. Furthermore, when corrected for energy intake in the feed the total heat production of the lactating animal drops below that of the dry animal at 72 hours.

[5] While thyroxine and the pituitary and adrenal hormones are referred to in this connection merely as an example, they are also thought to be important factors in lactation stimulus.

SUMMARY

Preliminary data obtained by an open-circuit-mask respiration method indicate that the total heat production of a lactating cow during fasting is about 10 per cent higher than that of a dry cow. Up to 60 hours of fast the heat production curves of both animals are essentially parallel, reaching a level at about 36 to 48 hours after feed. After 60 hours the heat production of the lactating animal further declined about 20 per cent. Certain data indicate that the higher level of total energy metabolism in the lactating cow is in a large measure due to heat increment of nutriment.

During 72 hours of fast, the lactating cow continued to produce a relatively constant amount of milk fat, although her milk yield declined about 50 per cent. It is believed, therefore, that within the limits of these experiments, lactation as a mechanism was unchanged by fasting.

Further investigation of digestion, absorption, and incident heat increment of nutriment appears to be necessary in order to evaluate true physiologic maintenance in the fasting ruminant. The probability of considerable absorption occurring 72 hours after food, suggests that the fasting level of total heat production is not an accurate measure of physiologic maintenance in the ruminant. Furthermore, differences in the speed of movement of alimentary residue during fasting, indicate that the fasting levels of total heat production in the lactating and dry cow are not comparable without further correction.

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EFFECTIVENESS OF ULTRAVIOLET LIGHT APPLIED TO THE HEAD OR BACK REGIONS OF CALVES

W. E. KRAUSS AND C. E. KNOOP
Ohio Agricultural Experiment Station, Wooster, Ohio

While considering an installation of ultraviolet lamps in a dairy barn the question arose as to the position of the lamps with respect to the cow's body. It was known that solar irradiation of the cow increases the vitamin D content of milk (1) as does irradiation with artificial sources of ultraviolet light (2, 3, 4) although the evidence on this point is conflicting (5, 6). Calves undoubtedly can use ultraviolet from solar or artificial radiation to alter their blood chemistry and mineral metabolism to such a degree as to prevent or cure rickets (7, 8, 9). From the work just cited, however, there is no means of determining what regions, if any, of the cow's body are particularly penetrable to ultraviolet light. In other species marked differences in the effectiveness of ultraviolet have been demonstrated by directing the radiation at different body sectors (10, 11, 12).

Of particular interest in this respect is the work of Knudsen (13) who showed that in rats radiation of the head region was much more effective than radiation of the back. He also found that the hair on the back probably was preventing absorption of the ultraviolet because when shaved areas were exposed marked antirachitic effects were obtained.

As preliminary, the work of Knudsen was partially repeated. Rachitic rats were irradiated for various periods with a Cooper-Hewitt lamp at a distance of 30 inches. In addition to substantiating the work of Knudsen the data in Table 1 suggest the significant point that if the radiation is continued long enough considerable ultraviolet penetrates the unshaved back.

TABLE 1

Response of rachitic rats to ultraviolet light

Part of body exposed	Length of exposure	No. of rats	Av. line test
	min.		
Head	120	2	3.00
Back (unshaved)	120	2	0.75
Controls	.....	2	0.00
Head	60	4	0.88
Back (unshaved)	60	4	0.38
Controls	.....	4	0.00
Head	30	2	0.00
Back (unshaved)	30	2	0.00
Back (shaved)	30	5	1.20
Controls	.....	3	0.00

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These findings with rats prompted a study with calves which, it was hoped, might throw some light on the question of placement of ultraviolet lamps in a dairy barn installation.

EXPERIMENTAL

Three groups of three calves each were used in this experiment. All the calves received whole milk in amounts sufficient to meet their needs during the first few weeks. They were then gradually shifted to liquid skimmilk which was fed at a maximum of 16 pounds daily. The calves were fed a grain mixture composed of equal parts ground yellow corn and ground oats. At the end of 120 days skimmilk feeding was discontinued. Water and salt were given free choice to all calves. The calves were penned in groups of three, each pen being provided with stanchions so that the animals could be treated as individuals. Raised slatted floors eliminated the use of bedding.

The calves in Group I were irradiated directly on the face and head by ultraviolet lamps placed in front of the head position of each calf as it stood in a stanchion. The calves in Group II were irradiated on the back by lamps placed above the center of the back region of each calf as it stood in a stanchion. In order to restriet the treatment to the desired region each group of calves was draped with a black cloth which prevented the light from striking anywhere but on the head region of the calves in Group I and screened the head region from the light in Group II. Group III served as controls and received no ultraviolet light. The lamps used were of special design to meet the needs of the set-up.[1]

Measurements were made monthly with an ultraviolet meter of the light intensity on the heads and backs of the respective groups. Readings were made at several points of the head and back areas. Any required equalization of ultraviolet intensity was accomplished by adjusting the height of the lamps in the back-irradiated group. The average intensity of ultraviolet light reaching the calves' heads was 82, and that reaching the calves' backs 84, micro-watts per square centimeter. The calves in Groups I and II were exposed to the lights for 45 minutes daily, including a 10 minute warming up period. It is estimated that the daily exposure to ultraviolet light was approximately equal to 2 hours of midsummer sunshine.

At the beginning of the experiment, and at approximately monthly intervals thereafter, blood samples were taken from each calf and the amount of calcium and phosphorus in the serum was determined. The Clark-Collip method for calcium (14) and the Bell-Doisy-Briggs procedure for phosphorus (15) were followed. At the same time blood from the calves of each group was pooled and dried before fans in a hot air chamber. These samples of dried pooled blood were later used for vitamin D comparisons, using the line test procedure.

[1] The lamps were furnished and the installation and ultraviolet measurements made by the General Electric Co., Nela Park, Cleveland, Ohio.

TABLE 2

Calcium and phosphorus in blood serum of calves
(Mg. per 100 cc.)

Date	Head group						Back group						Control group					
	1G		2H		3H		4H		5J		570H		6J		569H		581H	
	Ca	P	Ca	P	Ca	P	Ca	P	Ca	P	Ca	P	Ca	P	Ca	P	Ca	P
11/16/36	10.99	10.45	11.44	9.40	10.69	8.51	10.59	7.96	10.99	10.45	10.54	8.83	11.34	9.87	11.14	9.17		
12/14/36	9.54	8.20	10.59	9.40	10.74	8.08	10.89	8.08	11.24	10.25	9.34	8.60	10.04	6.99	6.48	9.93		
12/23/26																	11.75	10.80
1/11/37	Dead		10.34	10.00	10.19	8.93	10.89	9.25	10.84	9.57	6.83	8.53	5.82	9.94	5.47	7.88	10.34	9.13
1/21/37											6.98	6.77			4.62	8.65		
2/ 4/37															5.22	7.20		
2/ 8/37			10.79	8.98	10.57	8.26	9.90	8.05	11.14	8.73	Dead		5.57	8.37			8.73	9.33
3/ 9/37			11.10	7.73	10.56	8.18	10.47	7.40	10.13	8.88			5.67	7.47	Dead		5.72	8.33
4/ 7/37			10.42	8.37	10.27	6.70	9.34	7.50	8.85	7.73			6.31	5.56			6.31	7.57
5/14/37			Dead		Dead		10.22	6.95	Dead				Dead				5.86	5.42
							Killed										Killed	

After each calf died or was killed, the front and rear cannon bones and both eighth ribs were removed and freed of adhering flesh. The breaking strength of the left front and rear cannon bones was determined on an Olsen breaking machine, and the ash content of the distal end (one-third of the length) obtained after extraction with alcohol and ether. The same procedure was followed in determining the ash content of one-tenth of the rib bones, measured from the costochondral end.

The blood calcium and phosphorus data are presented in Table 2. Calf 1 G (head group) refused to eat and died, probably from starvation, early in the trial. Of outstanding significance is the difference between the values for Groups I and II and those of Group III. The control calves developed a blood picture indicative of rickets of the low calcium type. The blood calcium and phosphorus values of the irradiated calves are for the most part within the range of normality except for Calf 570 H, which died at the age of 2½ months from an injury obtained during a violent convulsion. At the time of death the calcium level of this calf's blood was rather low. The other two calves in this group showed normal blood pictures at the time of the death of 570 H. This fact, plus the rather variable results for calcium on calf 4 H, indicating possibly that it was on the borderline, and the somewhat lower calcium value on 5 J shortly before it died, indicates that the back-treated calves did not respond quite as well as did the head-treated calves.

The data in Table 3 substantiate this to some extent. During the first part of the experiment the vitamin D potency of the pooled blood from the

TABLE 3

Vitamin D potency of dried blood (line test procedure)

Date	Amount fed	Line test values		
		Head	Back	Control
	mg.			
11/16/36	500	0.0	0.0	0.0
	1000	0.0	0.0	0.0
	2000	0.0	0.0	0.0
	3000	0.0	0.0	0.0
1/11/37	2000	0.25	0.0	0.0
	3000	0.50	0.15	0.0
2/ 8/37	2000	0.70	0.17	.....
	3000	.....	.....	0.0
	4000	.....	.....	0.0
3/ 9/37	2000	0.53	0.64	.....
	3000	.....	.....	0.0
	4000	.....	.....	0.0
4/ 7/37	2000	0.13	0.25	.....
	3000	0.20	0.25	0.0
	4000	.....	.....	0.0

head-irradiated calves was definitely greater than that of the back-irradiated calves, but towards the end of the experiment there was no measurable difference. This might indicate that at first radiation of the head region was more effective, but as the treatment continued the calves in the back group caught up. It must also be considered that Calf 570 H, whose blood had been running low in calcium, did not contribute blood to the last two pooled samples.

TABLE 4

Ash content and breaking strength of bones

Group	Calf	% ash in bones		Days on exp.	Breaking strength of cannon bones	
		Leg	Rib		Front	Rear
		First analysis—All calves considered				
Head	1	59.52	64.53	58	800	903
	2	58.75	53.02	163	1195	1700
	3	58.53	50.95	148	1135	1458
	Av.	58.93	56.17		1043	1354
Back	4	58.89	52.10	186	1035	1472
	5	55.63	49.56	154	864	1100
	570	52.12	41.12	70	846	1405
	Av.	55.55	47.59		915	1326
Control	6	54.30	34.98	146	812	1142
	569	54.27	46.84	82	1182	1372
	581	51.71	35.67	148	736	1136
	Av.	53.43	39.16		910	1217
		Second analysis				
		Calves on experiment 5 months or longer				
Head	2	58.75	53.02	163	1195	1700
	3	58.53	50.95	148	1135	1458
	Av.	58.64	51.99		1165	1579
Back	4	58.89	52.10	186	1035	1472
	5	55.63	49.56	154	864	1100
	Av.	57.26	50.83		950	1236
Control	6	54.30	34.98	146	812	1142
	581	51.71	35.67	148	736	1136
	Av.	53.01	35.33		774	1139

The over-all effect of the various treatments is shown by the data in Table 4. These data may be treated in two ways: 1) when all calves were included; 2) when only those calves on experiment 5 months or longer are included. When the data on all calves are included an appreciable difference is shown between the bone ash content of the head-irradiated group and the back-irradiated group, although no difference in breaking strength is apparent. Again the inclusion of data from Calf 570 H is responsible for the apparent poorer performance of the back-irradiated group. When the data from the calves on trial for 5 months or longer are considered the difference in bone ash between the head group and back group is not signifi-

cant, but breaking strength values favor the head group. No matter which method of treatment is applied both the head and back groups show much better skeletal development than the calves in the control group. This superiority must be attributed to the light treatment.

DISCUSSION

Lower blood calcium and phosphorus, decreased bone ash and breaking strength, lack of vitamin D in the blood, enlarged knees and rib ends, stiffness, and a humped back posture, were symptoms in the control calves indicative of rickets. All the calves exhibited anorexia and failed to grow after skimmilk feeding was discontinued. The feeding of dry yeast did not increase grain consumption.

Most of the calves exhibited tetanic convulsions towards the latter part of the experiment. In a few instances following the spasm the calf would pass into a coma and die, or, if the coma was prolonged, the animal was killed. Magnesium determinations made on the blood just previous to or during a convulsion or coma gave values in most instances under 2.0 and as low as 1.6 mg. per 100 cc. These are below the normal values given for calves by Duncan, Huffman, and Robinson (16). The production of low-magnesium tetany was probably due to insufficient magnesium intake and could not be associated with the light treatment.

So far as practical application of these findings is concerned it would seem that a satisfactory installation of ultraviolet lamps would be one which utilized the greatest possible exposed surface. It would need to be assumed, of course, that cows utilize the ultraviolet in the same manner as do calves.

CONCLUSIONS

Ultraviolet light from artificial sources, of sufficient intensity to equal approximately the radiation received from two hours of midsummer sunshine daily, is effective in preventing rickets in young calves fed a rickets-producing ration.

Ultraviolet light applied to the region back of the withers and with the greatest intensity on the center of the back, is almost as effective as when an equivalent amount is applied to the head region of calves.

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NATURE OF THE SWELLING IN THE UDDER OF A COW AT CALVING TIME

W. W. SWETT, C. A. MATTHEWS AND R. R. GRAVES

Division of Dairy Cattle Breeding, Feeding, and Management Investigations, Bureau of Dairy Industry, United States Department of Agriculture[1]

Dairy cows differ greatly with respect to the amount of swelling in and near the udder at calving time. In some cases the udder undergoes a moderate increase in size but otherwise little visible change. In others it becomes swollen—sometimes to the point of extreme distortion. Not infrequently a "plastic" condition develops that may be limited to the lower portion or may involve a large part of the surface of the udder. The term "plastic" is used to denote a condition wherein localized external pressure, as with the fingertips, leaves a persistent indentation. This condition is often referred to as "pitting." A pronounced case is illustrated in Fig. 1. This kind of swelling usually is cool to the touch. Sometimes the swelling

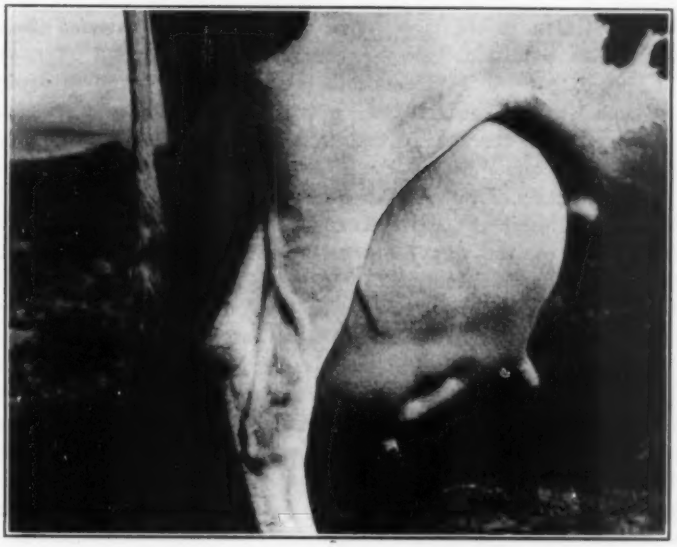

FIG. 1. Udder with pronounced "plastic" swelling at calving time. Note the persistent indentations resulting from pressure with finger tips. This condition is often referred to as "pitting."

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[1] Acknowledgment is made to S. R. Hall, Assistant Histologist, Division of Nutrition and Physiology, for preparing the slides from which the photomicrographs in Plate 5 were made.

disappears in a few days. Sometimes it persists in some degree for several months.

There is much to indicate that the kind of swelling described is the result of edema. By definition edema is an infiltration of serum in a part. A medical dictionary[2] lists 25 or more different types of edema that occur in humans. It seems to be caused by a great variety of disturbances to the physiological functions of the individual. Lymphedema is a swelling of soft tissues resulting from an increased quantity of lymph. Stoppage of lymph circulation, which is known as lymph stasis, results chiefly from some obstruction which causes the lymph to seek new channels. It appears to be conducive to fibrosis (development of fibrous tissue) which produces further stasis and still more fibrosis.[3] It might be expected, therefore, that repeated edematous swelling would tend to produce large, fibrous udders in cows with advance in age.

An edematous condition involving the udder and sometimes extending forward to the umbilicus and more rarely to the brisket, has been found by Parshall[4] in certain cases of acute gangrenous mastitis. It was found accompanied by coagulated blood-like material in the cisterns, multiple abscesses, blood clots in the large veins, gas pockets in scattered areas and necrosis. This condition, however, occurred most frequently between the second and sixth months of lactation. One case was found in a dry cow and only one in twelve occurred at the time of parturition. Bacteriological examination of the udders showed a mixed infection of *Staphylococcus aureus* and some anaerobes of which *Clostridium welchii* was the most important. Injections of pure cultures of either one of these organisms produced only mild cases of mastitis, but injections of both together resulted in marked edema on the day following injection, and typical gangrenous mastitis in 3 of 6 cows inoculated.

Correspondence has recently been carried on with authorities on edema and on lactation in women to learn whether or not a condition analogous to that found in cows at calving time occurs in the breasts of women at childbirth. One reply states that such a condition has not been observed in women. Another indicates that occasionally some edematous swelling does occur in the human breast at parturition, which is thought to be a lymphatic condition. Apparently it does not occur with sufficient frequency or severity to be considered a serious disturbance in the human.

As a rule udders showing an abundance of the swelling incidental to calving, are not available for post-mortem anatomical study, as dairy cows are

[2] Gould's Medical Dictionary (Scott) Second Edition. P. Blakiston's Son & Co. Philadelphia, Pa. 1928.

[3] Allen, E. V. and Ghormley, R. K. Lymphedema of the Extremities. Annals of Internal Medicine, 9, No. 1, pp. 516–539. 1935. From the Mayo Clinic.

[4] Parshall, C. J. Nature of Experimentally Produced Gangrenous Mastitis in Cows. Cornell Veterinarian, Vol. 24, April 1934. pp. 146–155.

seldom slaughtered at such an early stage of lactation. However, an opportunity was provided for slaughtering a cow that was showing at the time, an extremely congested condition of the udder. The cow was No. 848, a registered Holstein-Friesian, bred and raised in the herd of the Bureau of Dairy Industry, Beltsville, Md.

The usual procedure with all heifer calves in the breeding herd of the Bureau of Dairy Industry, at the Beltsville, Md., Station, is to commence periodic examinations of the comparative development of the mammary gland at an early age. At each examination the status of mammary gland development is graded. Nine grades, ranging from 1 to 9, are used for this purpose. A grade of 1 indicates an extremely retarded development, grade 9 is applied to the most advanced development, grade 5 represents the average development, grades 2, 3 and 4 are below average and grades 6, 7 and 8 are above.

As a young calf the mammary development of No. 848 was definitely below average. Grades of 3 were assigned both at 16 days and at 1 month 27 days of age. At 3 months 2 days the glandular development was graded 2 and the condition was noted as follows: "Udder tissue development appears to be very much retarded. Still in the straight tube stage. About the same development usually found at 2 weeks of age." At all subsequent observations up to the age of 1 year the stage of mammary gland development was below average though some progressive improvement was made and at 18 months the mammary development was definitely above the average. At each observation the udder was characterized by uniformity in the development of the individual quarters and at each examination made between the ages of 9 and 18 months inclusive, the glandular tissue was well attached to the abdominal wall.

Four examinations of the udder were made (Sept. 11 to October 26, 1931) previous to her first calving on November 3, 1931. At the first examination some swelling was noticeable, a grade of 3 for quantity being assigned. The quantity increased steadily, a grade of 5 being given on October 6, a grade of 8 on October 21, and a grade of 9 on October 26—8 days before calving. On October 26 this cow also showed a "very large area of abdominal swelling". After calving the swelling diminished rather steadily, only a very small quantity remaining on February 11, 1932, and only a trace on subsequent monthly observations until August 18, after which it appears to have disappeared entirely. The swelling was moderately plastic in character from October 21 to November 18, 1931.

Udder examinations were not made during the second or third lactation periods, but photographs taken near the time of each calving showed a strong tendency for this cow to develop swelling in the udder at each calving. This was particularly the case at the time of the fourth calving when the size of the udder reached extreme proportions. (Fig. 2.)

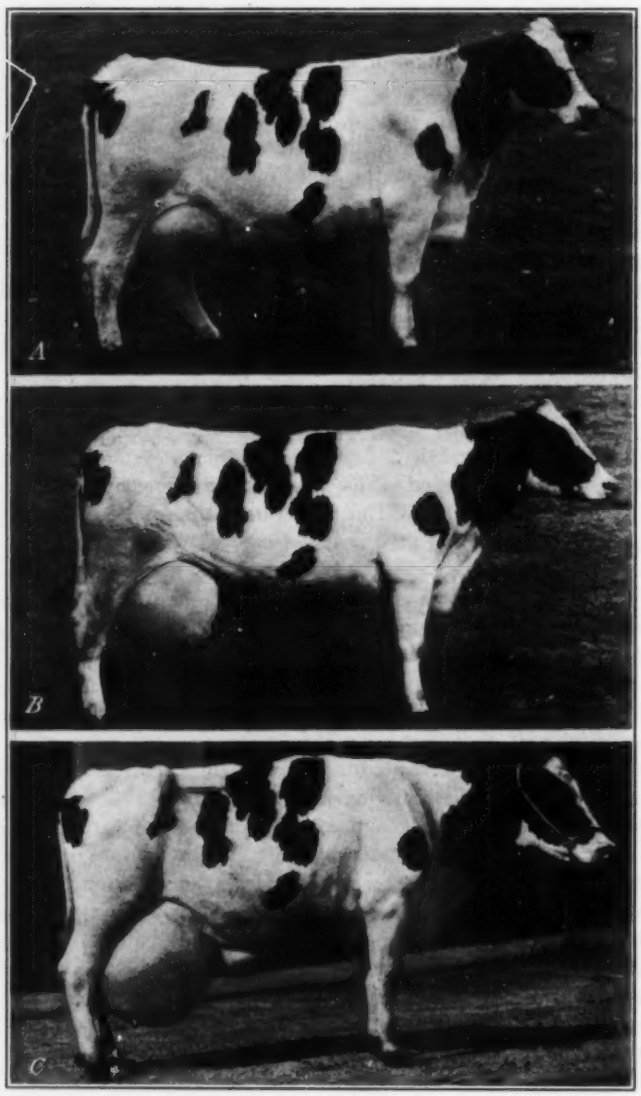

FIG. 2. Cow No. 848 showing edematous swelling on udder and abdomen. A. Five days before calving as a 3-year old. B. Seven days after calving as a 4-year old. C. One day after calving as a 5-year old.

Comments made by the men who milked this cow both by hand and by machine are interesting. She was milked by hand during a large part of her third lactation. The milker states that it was not particularly difficult to squeeze the milk out of the teats but that owing to the short teats and the hard swollen layer at the lower part of the udder, the milking had to be done by stripping between the thumb and finger and 25 to 30 minutes was required for milking. He volunteered the opinion that the swollen condition existing 5 days after calving would have been present to nearly the same extent 5 months after calving, as her udder always stayed hard on the bottom. The machine operator who milked the cow during her first lactation stated that this cow's udder was always hard.

The cow was slaughtered June 11, 1935, after her fourth calving which took place on June 6. Examination of the udder after milking on the morning of slaughter showed it to be of extreme size and to have a very large amount of swelling of a plastic nature. The udder was comparatively poor in shape as Figure 2 shows. It was amputated as quickly as possible after death, and subsequently was filled with formalin and frozen according to the plan regularly followed with cows slaughtered at the Beltsville Station. Although milked out before the cow was killed, the amputated udder weighed 165.65 pounds. This represents 10.9 per cent of the live weight of the cow on June 7—the day the last photograph in Fig. 2 was made.

The procedure followed in post-mortem studies of the udder is to fill the two quarters on one side of the udder simultaneously with formalin under constant pressure. Comparatively few cases (not more than 20 per cent) require more than 7½ minutes to fill the two quarters of the udder, but owing to the extreme size of this udder the filling was continued for 12½ minutes. At the end of that time 24,580 cc. of formalin had flowed into the two right quarters of the udder. Assuming that both halves of the udder had the same capacity the entire udder would have held 49,160 cc. which is equivalent in volume to 111.72 pounds of milk—the calculated capacity of this udder. As soon as filling was terminated the left half (unfilled) was separated from the right half by cutting along the left side of the median septum. The nature of the swelling could be clearly discerned when this incision was made. Apparently it was outside and separate from the glandular tissue, which seemed to be unaffected. The layer of swelling was about 2 inches thick. Describing its appearance is somewhat difficult but it seemed to consist chiefly of clear transparent fluid through which ran a net-work of fine silky fibers, glistening in appearance, that resembled spider's web. The fluid was held in some manner by this lacy structure and no appreciable amount escaped at the time the incision was made. The right half of the udder was immediately placed in a freezing room at a temperature of approximately 10° F., where it was kept until March 11, 1936. On that date it was cut with a band saw into vertical transverse sections approximately 1 inch thick.

After having been kept in a refrigerated room for 12 months the appearance of the layer of swelling was essentially unchanged, the fluid still being held in some manner by the tissues or by the lacy structure noted on the day of slaughter. Apparently the swelling was edematous in character, and the swollen material will subsequently be referred to as edematous tissue. Photographs of the cut surface of these sections were made according to our usual procedure on June 12, 1936. Although these photographs showed the glandular tissue in splendid detail, the lacy structure within the edematous tissue was less clearly brought out. The structure in the vertical transverse plane directly above the rear teat is shown in Fig. 3.

One of the sections was again photographed on March 30, 1937, more than 21 months after the cow was slaughtered, in an attempt to show the structure of the edematous tissue in greater detail. Even after this extended period the tissue did not appear to be appreciably changed. The appearance of both the glandular and edematous areas in this section is shown in Fig. 4, which represents a vertical plane directly above the front teat. The line of separation between the two areas is quite distinct, although there is some indication of a trace of edema in the strands of fiber running through the glandular tissue along the lower edge of the glandular area. To give an idea of the quantity of swelling present it is noted that the distance from the tip of the teat to the end of the skin covering the udder shown at the upper left, measured 17 1/16 inches. Attention is called to the manner in which the hide is pushed away from the glandular tissue, the way in which the right and left halves of the udder have been pushed away from each other, and the extent to which the teat is surrounded and seemingly shortened by the edematous swelling. The apparent shortening of the teat is shown to even better advantage in Fig. 3.

The tenacity with which the fluid was held by the edematous tissue is shown by the lack of change which occurred during the 21 months following slaughter, more than a year of which was after the udder was sectioned. When the udder sections were exposed to warm air, however, there was an evaporation of the suspended fluid and the areas that had appeared to consist primarily of fluid came to resemble a mass of loosely connected fiber.

Small blocks of the fresh tissue were removed on the day of slaughter from the half of the udder not filled with formalin, to be used for histological study. Blocks No. 1 and No. 2 were located $3\frac{1}{2}$ and $10\frac{1}{2}$ inches respectively above the front teat; and No. 3, No. 4 and No. 5, $3\frac{1}{2}$, $9\frac{3}{4}$ and $16\frac{1}{4}$ inches respectively above the rear teat. Before the histological studies were completed some evaporation of the preserving solution occurred and blocks Nos. 4 and 5 were spoiled. Slides were made from blocks 1, 2 and 3, of which representative areas are shown in Fig. 5, A, B & C. The structure of the edematous tissue obtained from one of the frozen gross sections and photographed at the same magnification as the other histological areas, is shown in Fig. 5, D.

FIG. 3. Gross structure of udder tissue in vertical transverse plane through the rear teat, showing thick layer of edematous swelling along the base between the gland tissue and the skin. Note how the teat appears to be shortened.

FIG. 4. Gross structure of udder tissue in a vertical transverse plane through a front teat. Although this surface was photographed more than 12 months after the udder was sectioned, the appearance is essentially unchanged.

Although the appearance of areas A and C which were taken from locations only a short distance above the front and rear teats differs somewhat from area B, which was located not far from the abdominal attachment of the front quarter where the tissue might be expected to be more actively secreting, these areas are entirely different in structure from area D which was taken from the edematous tissue. Apparently the edematous swelling does not invade the glandular tissue to any appreciable extent but is confined chiefly to the space between the mammary gland and the skin.

A part of the routine that is followed in connection with the post-mortem studies of the cow udders at the Beltsville Station involves a number of tests of the tissue after it has been filled with formalin, frozen, and cut into gross sections approximately one inch in thickness. Discs having an area of 6.25 square inches, are cut from certain gross sections at definite locations. Among the several determinations made are tests of the sponginess of the tissue of different udders and of the tissue from different parts of the same udder. The discs are soaked in water under vacuum, weighed, subjected to a pressure of 312.5 pounds to eliminate most of the water and weighed again. They are then resoaked as before and reweighed after which the degree of recovery and the amount of fluid taken up and held by the tissues per unit of pressed weight are determined.

After pressing and resoaking the weight of the discs taken from the glandular tissues of the udder from cow 848, averaged 97.7 per cent and those from the edematous tissue averaged 96.6 per cent of the soaked weight before the pressure was applied, indicating a very high recovery. The edematous tissue, however, was decidedly more spongy than the glandular tissue of this udder as it took up a quantity of water equal to 4.41 times its pressed weight as compared with an average of 1.91 times its pressed weight for the glandular tissue from a number of different locations. The pressed edematous tissue was particularly dry in appearance and seemed to consist almost entirely of loosely connected sheets or layers of light colored connective tissue running nearly parallel to each other. Air-dried edematous tissue was found to be only 41 per cent as heavy as air-dried glandular tissue. The air-dried weight was only 7 per cent of the weight before pressing for the edematous as compared with 16 per cent for the glandular tissue.

There has long been a question as to whether or not intense swelling of the udder at calving time is objectionable. Observations of A. G. Van Horn, Superintendent at the Woodward, Oklahoma, Station of the Bureau of Dairy Industry, indicate that the daughters of one sire used at that Station were particularly subject to intense and persistent swelling and that the swelling prevented a number of animals from reaching their maximum producing ability. Apparently the swelling described by Van Horn was edematous in character and similar to the condition described in connection with cow No. 848. Frequently it was accompanied by abdominal swelling, especially in

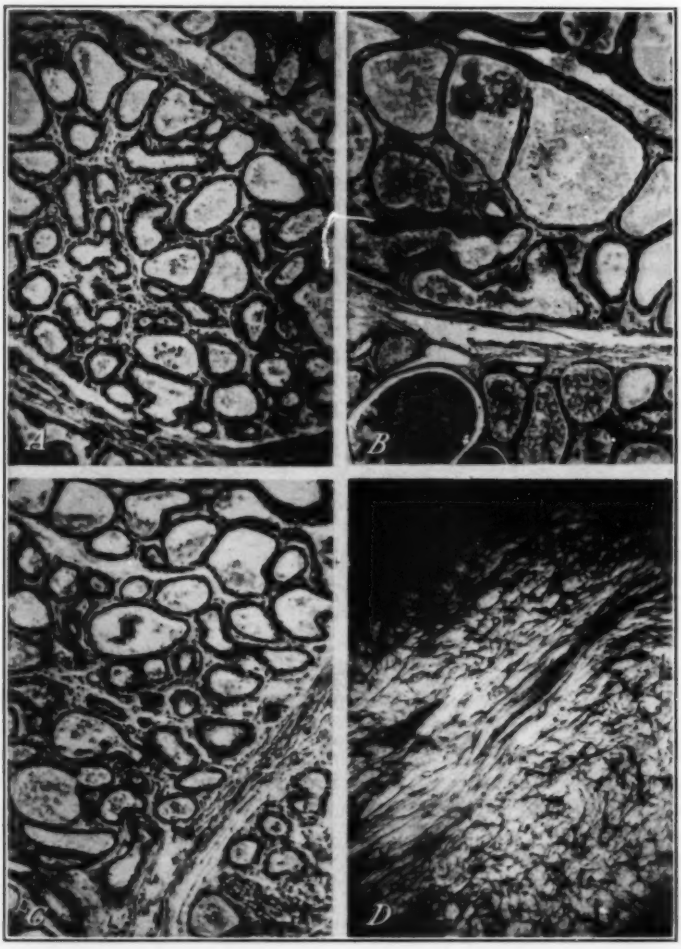

FIG. 5. Photomicrographs of mammary gland and edematous tissue: A, gland tissue from lower portion of front quarter; B, gland tissue from upper portion of front quarter; C, gland tissue from lower portion of rear quarter; D, edematous tissue.

young cows. It was reported that the swelling remained longest in the poorest attached udders.

As previously indicated cow No. 848 habitually showed edematous swelling at each parturition. Photographs taken 5 days before second calving, 7 days after third calving and 1 day after fourth calving give some idea of the extent to which it occurred. The one taken before second calving shows not

only considerable udder swelling but a definite abdominal swelling in the region of the navel. (Fig. 2.)

In production, cow No. 848 was somewhat erratic. During the first lactation which commenced at 2 years 1 mo., she reacted to the agglutination test (Bang's disease) and was moved to other quarters but was continued on the same schedule of feeding and milking and did not appear to suffer any marked reduction in milk flow. Her production, however, was low—never going above 42.5 pounds on any day—and amounted to only 5698 pounds of milk and 187 pounds of butterfat in 365 days. Calving again at 3 years 3 mos. of age she reached a high point of 80.2 pounds of milk in one day and produced a total of 11,695 pounds of milk and 377 pounds of butterfat in 323 days. In her third lactation, at 4 years 5 months, her highest production for a single day was 74.0 pounds of milk and her total for 365 days was 15,200 pounds of milk and 520 pounds of butterfat.

Routine studies of the rate of milking with a milking machine indicated that she was a slow milker. Timing studies were carried on during the first, second and third lactations. At the first 2-day timing, 121 days after first calving she was producing an average of 22.8 pounds of milk daily. The time required for milking was 8.35 minutes, 31.4 per cent of which was spent in massaging, and 20.8 per cent of the total yield of milk was obtained during the massaging period. At the second 2-day timing, which occurred 119 days after second calving, her average production was 42.25 pounds of milk daily, the time required for milking was 9.75 minutes of which 31.2 per cent was spent in massaging the udder, and 38.3 per cent of the total yield was obtained during the massaging period. The third timing occurred 49 days after third calving, when she was producing an average of 71.75 pounds of milk daily. This time 13.10 minutes was required for milking. Only 2.8 per cent of that time was spent in massaging and the massaging yielded only 0.6 per cent of the total quantity of milk.

CONCLUSIONS

Aside from the edematous swelling there was nothing about the appearance of the udder of cow No. 848 at any time to indicate any significant abnormality and all four quarters of the udder were functioning at the time of slaughter. The point that stands out as of particular interest is the fact that the intense swelling, which occurred in the udder of this cow at calving time apparently was edematous in nature, and that it did not appear to invade or affect the secreting tissue to any appreciable extent, but on the contrary was confined chiefly to the space between the glandular tissue and the skin.

THE BREEDING EFFICIENCY OF PROVED (AGED) SIRES

J. R. DAWSON

Bureau of Dairy Industry, United States Department of Agriculture

How many years of usefulness can be expected from a dairy sire that is 5 years of age or older? How frequently can such a sire be used successfully? Do seasonal changes have any effect on the breeding efficiency or fertility of aged sires? What effect if any does moving, and the subsequent change in environment, have on the usefulness of an old sire?

The Bureau of Dairy Industry has not only used proved sires in its various experimental station herds for a number of years, but it has probably used more proved sires than any other institution. Recognizing that the records of these sires might disclose some information with which to answer these questions, the author has analyzed the service records of 20 proved sires used in the station herds. The results of the study are reported in the following pages.

SOURCE AND NATURE OF THE DATA STUDIED

The data for this study were collected from the breeding records of the Bureau's experimental herds at Jeanerette, La., Lewisburg, Tenn., Hannibal, Mo.,[1] Columbia, S. C.,[1] Huntley, Mont., Mandan, N. Dak., Woodward, Okla.,[1] and Ardmore, S. D.[2]

The study includes the breeding records of 20 proved sires for which the data were complete and known to be accurate. Other proved sires were used to a limited extent in these herds, or for short periods, and they will be referred to in the discussion.

The data do not afford a comparison between young and old sires because very few young sires have been used and only for short periods. Neither was it possible to determine the breeding condition of the females in these herds, except in a general way. All the herds were managed by experienced men, most of whom were capable of treating ordinary breeding troubles. Veterinarians were employed for the most difficult cases, and it is believed that breeding trouble with females was no more serious in these herds than in the average breeding herd. The herds were subjected periodically to tests for Bang's disease. There was an occasional female reactor in some of the herds. None of the bulls included ever reacted to the Bang's test.

In this study, the breeding efficiency or fertility of a sire, as indicated by the number of services per conception when the sires were mated to fertile females, is expressed both by ratios and by percentages.

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[1] Dairy work at these stations is in cooperation with State agricultural experiment stations.

[2] Dairy work at this station was discontinued in 1932.

The data were tabulated and arranged to show breeding efficiency or fertility, by months, by years, and by ages, for the 20 sires during the time they remained fertile and in service in the station herds. The services to all cows include those to fertile cows, sterile cows, and to cows in which pregnancy was doubtful, and are of interest in showing whether there is any relation between frequency of service and breeding efficiency.

For the purpose of this study a female was considered fertile up to the time of her last conception, no matter how many times she was bred for her last conception or to how many sires. All services to a cow, after her last conception, were credited to the bulls as services to a sterile female unless it was definitely known that the cow was pregnant.

In a few cases, sires were continued in service for some time after they became sterile because the fact that they were sterile was not evident at the time. All services credited to a sire, after he got his last conception are omitted from the comparative study. Only services occurring after a sire was 5 years of age are included in the tabulation.

Sires Studied

For convenience in presenting the data, the 20 sires have been numbered from 1 to 20. Table 1 gives the breed of each sire, his age when he began service in the station herd, his age when his use was actually discontinued, his age when he was judged infertile, and the length of his fertile service in the station herd.

The 20 sires include 8 Jerseys, 2 Guernseys, and 10 Holsteins. With the exception of sires 9, 11 and 14, all these bulls were proved sires when they began service in these station herds, and they varied from 5 to 10 years of age at the time. Sires 9, 11 and 14 were started in service as young unproved bulls, but were proved later.

FEEDING AND MANAGEMENT OF THE BULLS

All the bulls had been moved to the station at which they were used shortly before the start of their service. Bulls 3, 5 and 6 were moved rather short distances by truck, but the others were shipped several hundred miles by train. This movement was necessarily accompanied in most cases by abrupt changes in environmental and climatic conditions.

Attention is directed to the wide range of climatic conditions at the stations where these bulls were in service, as this may have a bearing on some of the points discussed later.

All the bulls were kept in strong pens and were allowed to run in or out of a shed at will. The rations varied somewhat according to the station. A good quality of legume hay was fed, but was given in limited amounts if the bull was inclined to develop a large middle. Grain, usually the mixture fed to the regular herd, was fed in sufficient amounts to keep the bulls in

TABLE 1

Age of the 20 sires when they started service in the Bureau's station herds, age when their use was discontinued, age when they were judged infertile, and the length of their fertile service in these herds after they were 5 years old or older

Sire No.	Breed	Age when service began in these herds	Age when use was discontinued	Age when sire was judged infertile	Length of fertile service in the herd, after 5 years of age	Station where sire was used
		Yr.–Mo.	*Yr.–Mo.*	*Yr.–Mo.*	*Yr.–Mo.*	
1	Jersey	5–11	10–9	10–9	4–10	Jeanerette, La.
2	Jersey	8–3	13–5	13–3	5–0	Jeanerette, La.
3	Jersey	7–1	(1)	(1)	(1)	Hannibal, Mo.
4	Jersey	10–5	15–2	14–6	4–1	Lewisburg, Tenn.
5	Guernsey	10–3	13–3	13–3	3–0	Columbia, S. C.
6	Guernsey	7–3	13–10	12–0	4–9	Columbia, S. C.
7	Holstein	6–10	12–3	12–3	5–5	Huntley, Mont.
8	Holstein	5–5	10–7	(2)	5–2	Mandan, N. Dak.
9	Holstein	4–4	8–0	(2)	3–0	Huntley, Mont.
10	Holstein	6–2	11–4	11–2	5–0	Mandan, N. Dak., and Huntley, Mont.
11	Holstein	1–5	6–10	(2)	1–10	Woodward, Okla.
12	Holstein	6–0	12–5	12–5	6–5	Woodward, Okla.
13	Holstein	5–4	9–11	(2)	4–7	Woodward, Okla.
14	Holstein	3–8	16–1	16–1	11–1	Huntley, Mont., and Ardmore, S. D.
15	Jersey	7–2	8–9	8–9	1–7	Jeanerette, La.
16	Jersey	7–9	10–0	10–0	2–3	Jeanerette, La.
17	Jersey	7–9	9–10	9–10	2–1	Jeanerette, La.
18	Jersey	7–11	12–0	12–0	4–1	Jeanerette, La.
19	Holstein	6–8	(1)	(1)	(1)	Woodward, Okla.
20	Holstein	6–11	(1)	(1)	(1)	Mandan, N. Dak.
Average		6–8	10–10[3]	12–0[4]	4–5[3]	

[1] Still fertile and in active service as of May 31, 1937.
[2] Fertile when disposed of.
[3] Average for 17 sires.
[4] Average for 13 sires.

fair condition. Silage was fed sparingly. The bulls were encouraged to exercise but no systematic plan of exercising was followed.

FEEDING AND MANAGEMENT OF THE COWS

The females in the various herds where the bulls were in service were fed and managed under desirable conditions. All cows on official test were given a good grade of legume hay and silage, and a grain mixture. As a rule, the cows on test received no pasture. The regular herd cows were fed legume hay, silage, and a limited-grain ration, and pasture. Many of the cows were in feeding experiments in which they received only roughage of good quality. Studies by the Bureau indicate that this practice does not affect the fertility or breeding condition of cows.[3] Pasturage at the stations varied in kind and quality, with the region and climatic conditions.

[3] Graves, R. R., and Dawson, J. R. Feeding Dairy Cows on Alfalfa Hay Alone. U. S. Dept. Agr. Tech. Bul. 610, 1938.

When cows were on test they were bred approximately 5 months after calving, whereas cows in the regular herd were bred 2 to 3 months after calving. Heifers were bred for the first time at approximately 15 months of age.

RESULTS AND DISCUSSION

Length of Fertile Service in the Herds

According to the data in Table 1, the 20 sires were started in service in these herds at the average age of 6 years 8 months. Eliminating sires 9 and 11, which were started in service as young bulls, the average age that the remaining 18 sires were started in service was 7 years, 1 month. Three of the sires are still in service and the average age of the other 17 was 10 years 10 months when their use was discontinued. Thirteen of the 20 sires died or were infertile at the time they were disposed of at an average age of 12 years. The average period of fertile service for sires in these herds was 4 years 5 months for services after the age of 5 years. Only 17 of the 20 sires were included in this average since sires 3, 19, and 20 are still in service.

In addition to the sires shown in Table 1, other proved sires were used in the station herds. Seven of these were victims of injury or disease after a short period of service, and two were frequently shifted from one herd to another so that the breeding data on these sires are not considered suitable to use in this study. The shortest period of service by any of the 29 sires was 8 months and the longest period of fertile service was 11 years 1 month by sire 14, not including his services prior to 5 years of age.

Sire 14 was fertile up to the time of his death at 16 years 1 month of age. A sire in the Bureau's herd at Beltsville, Md., was fertile to the age of 16 years 4 months. A sire in South Carolina[4] is reported as being in service and fertile at 17 years 1 month of age.

Fertility of the Sires

Table 2 shows the number of services to all cows, by each sire during the time he was used in the station herd, also the number of services to fertile cows only, and the number of conceptions obtained. The fertility of the sire is represented by the percentage of services to fertile cows that resulted in conceptions.

The 20 sires had a total of 3,585 services to all cows, of which 2,982 were to fertile cows. The total number of conceptions was 1,197. This is a ratio of 2.49 per conception, based on services to fertile cows.

The 20 sires varied in fertility, from a low of 21 per cent for sire 4 to a high of 71 per cent for sire 16. The average for the 20 sires was 40 per cent, and 10 of the sires were below the average for the group.

[4] Fern's Raider of Appin 64700, a Guernsey sire owned by C. S. McCall, Bennettsville, S. C. Information to the author through J. P. LaMaster, Clemson College, S. C.

TABLE 2

The relative fertility or breeding efficiency of the 20 sires during the time they were used in the station herds
(Only services after 5 years of age are included)

Sire no.	Services to all cows	Services to fertile cows	Conceptions	Breeding efficiency,[1] or fertility
	No.	*No.*	*No.*	*Per cent*
1	326	254	78	31
2	121	72	19	26
3	160	144	58	40
4	267	235	50	21
5	135	120	35	29
6	147	133	49	37
7	181	170	57	34
8	141	117	72	62
9	142	126	41	33
10	397	356	144	41
11	87	63	29	46
12	196	166	109	66
13	166	146	96	66
14	159	145	72	50
15	97	65	23	35
16	58	44	31	71
17	98	71	40	56
18	292	211	47	22
19	251	209	53	25
20	164	135	94	70
Total	3,585	2,982	1,197	—
Average	179	149	60	40

[1] Based on the number of services to fertile cows that resulted in conceptions.

Miller and Graves[5] reported the breeding records of 10 mature bulls and 18 young bulls used at the Beltsville, Md., station. The 10 mature bulls had 1,109 services to fertile females and got 289 conceptions, a ratio of 3.83 services per conception.

The ratios of services per conception, both in this study and in the Beltsville report, seem very high. The herds all have had breeding trouble at one time or another, as a result of infections of various kinds. These high ratios are undoubtedly due in part to the use of older sires and also to the fact that sterile cows are held longer in these herds, in an effort to get them to breed, than would be the case in most herds.

Effect of Age on Fertility

Table 3 gives the number of services to fertile cows, the number of conceptions, and percentage of services that resulted in conceptions, for the 20 sires according to age by 6-month periods starting at 5 years of age.

[5] Miller, Fred W., and Graves, R. R. Reproduction and Health Records of the Beltsville herd of the Bureau of Dairy Industry. U. S. Dept. Agr. Tech. Bul. 321. 1932.

TABLE 3

The effect of advancing age on fertility of sires

Age	Sires included	Services to fertile cows	Conceptions	Fertility[1]
Years	*No.*	*No.*	*No.*	*Per cent*
6-month period				
5 to 5½	5	46	24	52.2
5½ to 6	6	67	33	49.3
6 to 6½	8	100	52	52.0
6½ to 7	10	132	69	52.3
7 to 7½	12	220	89	40.5
7½ to 8	14	256	115	44.9
8 to 8½	14	256	121	47.3
8½ to 9	15	325	144	44.3
9 to 9½	15	324	131	40.4
9½ to 10	14	325	122	37.5
10 to 10½	13	219	74	33.8
10½ to 11	13	225	57	25.3
11 to 11½	10	122	49	40.2
11½ to 12	8	83	31	37.3
12 to 12½	7	64	20	31.3
12½ to 13	3	47	19	40.4
13 to 13½	4	89	20	22.5
13½ to 14	2	31	12	38.7
14 to 14½	2	31	8	25.8
14½ to 15	2	8	5	62.5
15 to 15½	....	....	....	....
15½ to 16	1	9	3	33.3
16 to 16½	1	3	1	33.3
2-year periods				
5 to 7	11	345	178	51.9
7 to 9	16	1057	469	44.4
9 to 11	18	1093	384	35.1
11 to 13	9	316	119	37.7
13 and over—	4	159	45	28.3

[1] Based on number of services to fertile cows that resulted in conceptions.

It is of interest to mention the extreme variation in fertility of the individual sires as age advanced. Sire 1, as one example, was 100 per cent fertile at the age of 5½ to 6 years, and his fertility dropped to 70 per cent during the following 6-month period. At the age of 6½ to 7 years, however, he got only 1 conception in 15 services to fertile cows, indicating a fertility of only 6.7 per cent. His fertility reached 51.9 per cent at the age of 8 to 8½ years, then dropped sharply to 19.1 per cent. During the 6-month period of his heaviest service, from 9½ to 10 years, his fertility was 32.6 per cent, when he got 15 conceptions out of 46 services. For the next 6-month period he got only 1 conception out of 34 services, indicating a fertility of only 2.9 per cent.

Sires 8, 12, 13, 16, and 20 for the most part had a high fertility throughout the years they were used.

Sire 14 remained fertile to the oldest age of any of the 20 sires. While there were a few periods when his fertility was low, he showed a high degree of fertility throughout most of his life and up to the time of his death at 16 years 1 month of age.

Table 3 also shows the relation of fertility to advancing age, by 2-year age periods. At 5 to 7 years of age, the fertility of the group was 51.9 per cent, decreasing to 44.4 per cent at 7 to 9 years of age, 35.1 per cent at 9 to 11 years of age, slightly increasing to 37.7 per cent at 11 to 13 years of age; with a further steady decrease to 28.3 per cent for services after 13 years of age. On the average there was a decided and consistent decline in fertility with advancing age, but the breeding records of the individual sires indicate that there is great variation in this respect and that conclusions based on averages should be carefully considered.

TABLE 4

The effect of frequency of service on fertility

Frequency of service (Services per sire per month)	Services to all cows				Services to fertile cows only			
	Number of sires included	Services	Conceptions		Number of sires included	Services	Conceptions	
No.	*No.*	*No.*	*No.*	*Per cent*	*No.*	*No.*	*No.*	*Per cent*
1	20	156	63	40.4	19	169	97	57.4
2	19	326	135	41.4	20	340	160	47.1
3	19	360	137	38.0	20	363	155	42.7
4	20	408	130	31.9	19	420	161	38.0
5	19	495	166	33.5	20	395	158	40.0
6	18	330	132	40.0	17	324	149	46.0
7	17	329	109	33.1	17	240	92	38.3
8	15	296	89	30.1	11	248	60	24.2
9	15	315	78	24.8	8	171	62	36.3
10	5	110	28	25.5	3	40	11	27.5
11	9	132	39	29.5	6	88	32	36.3
12	5	84	19	22.6	2	36	12	33.3
13	4	52	28	53.8	2	26	16	49.5
14	2	28	9	32.2	2	42	11	26.2
15	3	90	18	20.0	3	45	17	37.8
16	2	32	13	40.6	1	16	2	18.8
17	----	----	----	----	----	----	----	----
18	----	----	----	----	----	----	----	----
19	1	19	2	10.5	1	19	2	10.5
20	----	----	----	----	----	----	----	----
21	----	----	----	----	----	----	----	----
22	----	----	----	----	----	----	----	----
23	1	23	2	8.7	----	----	----	----
1 to 3, inc.	20	842	335	39.8	20	872	412	47.2
4 to 6, inc.	20	1233	428	34.7	20	1139	468	41.1
7 to 9, inc.	20	940	276	29.4	20	659	214	31.0
10 or more	14	570	158	27.7	8	312	103	33.0

Effect of Frequency of Service on Fertility

What effect does frequency of service have on the fertility of old sires?

Table 4 shows the number of services, to all cows and to fertile cows, the number of conceptions, and the fertility of the 20 sires, arranged according to the number of services per calendar month. Considering services to fertile cows only, the trend was decidedly toward a lower fertility as the number of services increased from 1 to 8 per month. As the number increased beyond 8, there did not appear to be any further decline in fertility. However, many of the sires showed just as high or higher fertility when used from 7 to 15 times a month as they did when used only once a month.

It is probable that the most pronounced effect of frequency of service on fertility will not be felt until a time following the period of service. With this point in mind, the data were tabulated by months and by sires according to the number of total services that particular sire had had during the preceding month. Table 5 gives the results of this tabulation.

TABLE 5

The effect of frequency of service in one month on the fertility of the sires during the following month

Services during preceding month	Number of sires included	Services to fertile cows, conceptions, and fertility for the following month		
		Services	Conceptions	
No.	*No.*	*No.*	*No.*	*Per cent*
No services	16	91	43	47.3
1 to 3, inclusive	20	949	423	44.6
4 to 6, inclusive	19	896	365	40.7
7 to 9, inclusive	18	666	230	34.5
10 and over	12	304	90	29.6

Sixteen sires had 91 services and secured 43 conceptions, indicating 47.3 per cent fertility, during months that followed months when no services were permitted. When 1 to 3 services were permitted per month, the fertility for the following month was 44.6 per cent. The decline in fertility on this basis of interpretation is rather rapid and consistent. When 10 or more services were permitted in one month, the fertility for the following month was 29.6 per cent. It would appear that a rest period of a month is of distinct benefit, and that as the number of services per month increases to 10 or more there is a decided and consistent drop in fertility the following month. Here again, however, was found great variation between individual sires.

It is a matter of interest to note that 24 per cent of all services to the 20 sires studied were at the rate of 1 to 3 per month; 35 per cent were at the rate of 4 to 6 per month; 26 per cent were at the rate of 7 to 9 per month; while only 16 per cent of all services were at the rate of 10 or more per month. One sire was used 23 times, during one month, and another sire was used 19 times.

Effect of Season on Fertility

Are old bulls more fertile at some seasons of the year than at others? Table 6 shows the number of services to all cows and to fertile cows, the conceptions, and the fertility of the 20 sires according to the month of the year in which the services were performed.

TABLE 6

The effect of season on fertility of sires

Month in which services occurred	Services to all cows	Services to fertile cows only	Conceptions	Breeding efficiency or fertility[1]
	No.	*No.*	*No.*	*Per cent*
January	291	235	94	40.0
February	263	227	97	42.7
March	311	262	107	40.8
April	323	262	116	44.3
May	340	279	110	39.4
June	281	237	90	38.0
July	310	266	115	43.2
August	281	233	94	40.3
September	251	205	80	39.0
October	313	261	108	41.4
November	307	262	85	32.4
December	314	253	101	39.9

[1] Based on services to fertile cows that resulted in conceptions.

There is a tendency for the fertility to be somewhat higher during the months of February, April, July, and October, when the fertility (based on services to fertile cows) averaged 42.9 per cent. The low trends come in June, September, and November, during which months the average fertility was 36.5 per cent. This difference of 6 per cent is probably of little significance, however, when one considers the wide range of climatic conditions obtaining at the stations where the sires were used (see Figure 1).

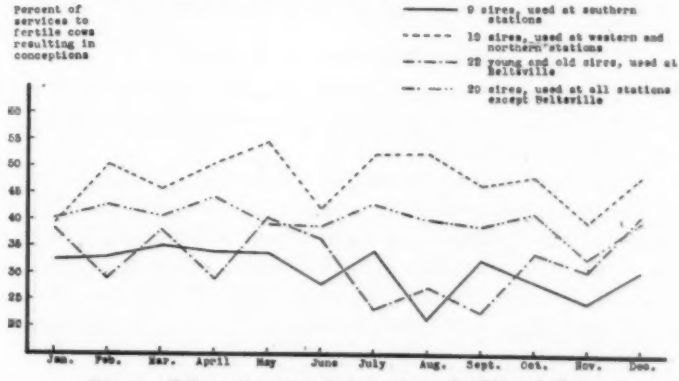

FIG. 1. Effect of season of the year on fertility of sires.

Miller and Graves,[6] in a study of 22 young and old bulls used only at the Beltsville, Md., station covering a period of 4 years and including 1,539 services to fertile cows, found the lowest fertility (23 per cent) in July and September, after which the fertility increased during the fall and winter months (see Figure 1). They suggested that the hot weather influences the functioning of the genital organs adversely and that increased genital efficiency seems to have been associated with the advent of autumn. This apparently was not the case when all of the 20 bulls included in this study are considered.

Because of the wide range of climatic conditions at the several stations, 19 of the sires were divided into two groups according to whether they were in service at a southern station or at western and northern stations. Nine sires (1, 2, 4, 5, 6, 15, 16, 17, and 18) were placed in the southern group, and 10 sires (7, 8, 9, 10, 11, 12, 13, 14, 19, and 20) in the western and northern group.

The fertility curves for the two groups follow the same general trend (see Figure 1), but the curve for the southern group follows that of the Beltsville group more closely than does the curve of the western and northern group. Climatic conditions at Beltsville are also more similar to those of the southern group of stations.

It is of further interest to note the decidedly lower range in fertility of the sires used at the southern stations as compared to those used at the western and northern stations. Those used at the southern stations had an average fertility of 36 per cent, while those used at the western and northern stations averaged 49 per cent. Higher temperatures during the summer with higher humidity generally prevail at the southern stations. At the western and northern stations during the summer the temperature rises quite high, but as a rule drops sharply at night. Lower humidity prevails at the western and northern stations than at the southern stations.

Effect of Moving on Fertility

Does the moving of sires for a considerable distance with the accompanying change in environmental conditions lower the fertility of old bulls and, if so, how long does this condition last?

Only 17 of the 20 sires are considered suitable for this phase of the study, because they were transported for considerable distances before their services as proved sires in the station herds began. Unfortunately, there is no accurate record of the fertility of most of them before they were moved. Table 7 shows the approximate distance in miles that the sires were transported, and the fertility by 3-month periods for 2 years following their initial service in the herds.

[6] *Loc. cit.*

TABLE 7

The effect of shipment and changes in environment on the fertility of 17 sires, as indicated at stated periods during the first and second year after arrival at the respective stations[1]

Sire number	Distance moved	Fertility of sires during first year											
		1 to 3 months			4 to 6 months			7 to 9 months			10 to 12 months		
		Services	Conceptions		Services	Conceptions		Services	Conceptions		Services	Conceptions	
	Miles	*No.*	*No.*	*Per cent*	*No.*	*No.*	*Per cent*	*No.*	*No.*	*Per cent*	*No.*	*No.*	*Per cent*
1	1,100	8	8	100.0	4	1	25.0	2	1	50.0	8	0	00.0
2	200	10	3	30.0	5	4	80.0	8	4	50.0	6	2	33.3
3	125	8	4	50.0	11	4	36.4	11	5	45.5	13	6	46.2
4	630	30	8	26.7	30	6	20.0	14	3	21.4	16	2	12.5
5	85	7	0	0.0	9	1	11.1	15	2	13.3	6	3	50.0
7	685	3	0	0.0	6	1	16.7	7	1	14.3	19	5	26.3
8	370	2	1	50.0	3	1	33.3	1	0	0.0	7	4	57.1
10	370	13	7	53.8	17	3	17.6	17	8	47.1	22	8	36.4
12	815	8	6	75.0	13	7	53.8	11	9	81.8	2	0	00.0
13	600	3	2	66.7	10	6	60.0	12	7	58.3	10	5	50.0
14	300	4	3	75.0	6	4	66.7	2	2	100.0	.....	.....	.....
15	1,100	2	1	50.0	10	4	40.0	15	3	20.0	11	2	18.2
16	835	1	1	100.0	5	2	40.0	.....	.....	.....	2	2	100.0
17	1,100	6	4	66.7	2	2	100.0	11	7	63.6	18	9	50.0
18	1,785	17	1	5.9	14	3	21.4	9	1	11.1	11	3	27.3
19	815	21	3	14.2	22	4	18.2	10	4	40.0	33	3	9.1
20	370	14	13	92.9	5	5	100.0	7	4	57.1	11	8	72.7
Total	.....	157	65	41.4	172	58	33.7	152	61	40.1	195	62	31.8

[1] All sires were transported in freight cars, except Nos. 3, 5, and 6, which were moved by truck.

TABLE 7—(*Continued*)

Sire number	Distance moved	Fertility of sires during second year											
		13 to 15 months			16 to 18 months			19 to 21 months			22 to 24 months		
		Services	Conceptions		Services	Conceptions		Services	Conceptions		Services	Conceptions	
	Miles	*No.*	*No.*	*Per cent*	*No.*	*No.*	*Per cent*	*No.*	*No.*	*Per cent*	*No.*	*No.*	*Per cent*
1	1,100	22	8	36.4	14	6	42.9	6	0	00.0	9	5	55.5
2	200	3	0	00.0	11	1	9.1	13	3	23.1	1	0	00.0
3	125	9	3	33.3	12	3	25.0	10	5	50.0	12	5	41.7
4	630	14	1	7.1	8	5	62.5	4	2	50.0	5	1	20.0
5	85	2	2	100.0	8	1	12.5	14	5	35.7	12	4	33.3
7	685	17	9	52.9	8	5	62.5	10	4	40.0	6	3	50.0
8	370	5	4	80.0	3	2	66.7	1	1	100.0	9	5	55.6
10	370	22	7	31.8	18	5	27.8	8	6	75.0	21	7	33.3
12	815	10	5	50.0	10	6	60.0	17	13	76.5	4	3	75.0
13	600	3	3	100.0	3	2	66.7	12	7	58.3	8	5	62.5
14	300	.....	.....	.....	6	2	33.4	9	4	44.4	3	2	66.7
15	1,100	17	7	41.2	6	4	66.7	4	2	50.0	.....	.....	.....
16	835	4	2	50.0	2	0	00.0	9	7	77.8	10	9	90.0
17	1,100	6	4	66.7	7	3	42.9	7	4	57.1	13	7	53.8
18	1,785	29	6	20.7	25	6	24.0	21	2	9.5	21	6	28.6
19	815	35	9	25.7	19	5	26.3	18	9	50.0	19	2	10.5
20	370	25	17	68.0	9	3	33.3	13	8	61.5	9	5	55.6
Total	.....	223	87	39.0	169	59	34.9	176	82	46.6	162	69	42.6

For the first 3 months following arrival at the stations the 17 sires had an average fertility of 41.4 per cent, which is remarkable because of the decline to 33.7 per cent at 4 to 6 months following arrival. The high average fertility immediately following shipment is unexplainable unless the time was too brief for the full effects of shipping and changes in environment to be exerted. Or possibly the change of environment may have had a temporary stimulating effect on fertility.

The lowest point in fertility (31.8 per cent) was 10 to 12 months after the bulls arrived, after which there was a decided trend toward higher fertility during the second 12 months of service in spite of the advancing age of the sires. The average fertility for the first year following movement of the sires was 36.4 per cent as compared to 40.7 per cent for the second year.

The individual sires offer interesting studies. Sire 1 showed 100 per cent fertility for the first 3 months following arrival, which was the highest for the 5 years he was used. He was moved 1,100 miles from Beltsville, Md., to Jeanerette, La., with a very decided change in climatic and other environmental conditions. Sires 5 and 7 got no conceptions for the first 3 months, but their fertility increased gradually from then on. Sire 5 was moved only 85 miles by truck, and there was practically no change in climatic conditions. While the average fertility is decidedly downward for the first year following movement of the sires and is decidedly upward for the second year, the individual variation is so wide that definite conclusions cannot be drawn.

SUMMARY AND CONCLUSIONS

Detailed service records of 20 proved sires used in 8 branch experiment station dairy herds are presented and the fertility of these sires after 5 years of age is expressed by the percentage of services to fertile cows that resulted in conceptions. Extra services and services to infertile cows are given separately. The data were tabulated and analyzed from the standpoint of (1) the relative fertility of the individual sires, (2) the effect of advancing age on fertility, (3) the effect of frequency of service on fertility, (4) the effect of season of the year on fertility, and (5) the effect of moving sires on their fertility.

Because of the extreme and inconsistent variation in fertility exhibited by individual sires on all phases included in this study, it is apparent that averages are of little value for application to individual sires.

SOFT CURD MILK*

A Critical Review of the Literature

F. J. DOAN
The Pennsylvania Agricultural Experiment Station,
Department of Dairy Husbandry

When milk from individual cows is coagulated with rennin and (or) pepsin, the toughness and adhesiveness of the coagulum varies widely with different animals. Some milk forms a soft, friable type of curd which might be described as "mushy." Other milk exhibits an extremely tough rubbery curd mass which fractures with difficulty. Milk with the former character of coagulum has come to be known as soft curd milk while that with the latter type of coagulum is known as hard curd milk.

The interest in soft curd milk has been increasing steadily since 1923 when Hill (35) proposed his test for determinating the curd character of milk as an index to its suitability for infant feeding. Previous to this time Washburn and Bigelow (81), Washburn and Jones (82), Buckley (9) and Alleman and Schmid (1) had pointed out marked differences in the coagula obtained with different milks when treated with digestive enzymes but, with the exception of Alleman and Schmid, none of these workers developed a means of accurately classifying the curd characteristics and their work was largely overlooked.

As early as 1913 Brennemann (6) explained the favorable results obtained with boiled milk in infant feeding on a curd character basis and intimated that other successful modifications of cow's milk for infant use depend primarily on the ability of the modifier to alter the physical properties of the coagulum (particularly the particle size) formed in the stomach after ingestion.

The interest of the milk distributors in soft curd milk has grown tremendously in the past few years and due to the fact that the use of evaporated milk in infant feeding has been increasing rapidly (largely at the expense of fluid milk), it is their desire to place on the market a fresh milk having digestion characteristics as suitable for infants as has the canned variety. They have been more interested in the subject since it has been found possible to modify or soften the curd character of average mixed milk by processing rather than having to resort to a selection of individual cows giving milk with the desirable characteristics, as originally suggested by Hill (36, 37, 39) and as practiced by dealers in several cities where soft curd milk has been sold for the past 10 years.

That the medical profession is alert to the possibilities of soft curd milk is evidenced by the approval of "Soft Curd Certified Milk" by the Amer-

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ican Association of Medical Milk Commissions and its endorsement by physicians and pediatricians in many places; also by the recent action of the Council on Foods of the A. M. A. in publishing a report concerning the nutritional significance of the curd tension of milk (18).

The purpose of this article is to review the subject of soft curd milk, to summarize the available information and to criticise it in a constructive manner.

THE CURD TEST

Hill's original test (35) for measuring the curd tension or curd toughness of milk has been criticised and modified by a number of workers (10, 15, 48, 58, 59) as well as by himself (9). Recently a committee of the American Dairy Science Association, after two years of study, has attempted to standardize the determination by reporting a tentative method (19). Briefly, this method substitutes N/10 hydrochloric acid, containing 0.45 per cent pepsin for the calcium chloride pepsin reagent originally used; adds tempered milk to the tempered coagulant in a 250 ml. beaker or 8 oz. mayonnaise jar; establishes 95° F. $\pm$ 1° F. as the coagulation temperature and 10 minutes as the coagulation interval; requires the addition of the 100 ml. charge of milk to the 10 ml. of reagent by means of a 100 ml. pipette with the tip removed so that it drains water in 4½ seconds, the milk to be added holding the pipette vertically over the center of the receptacle and blowing it into the coagulant in approximately 2 seconds with no further agitation; requires a knife of similar design to that used in the American Curd-O-meter with the same linear cutting surface; specifies that any, accurate instrument may be used which embodies an automatic movement either of the knife or receptacle, provided that the rate be approximately one inch in five seconds; and demands that the result be the average of two or more maximum readings checking within 10 per cent. If the test is carried out as described the pH of the whey from the cut samples will be between 5.95 and 6.10 depending on the buffer capacity of the milk.

It is the hope of the committee that this tentative method will eliminate the diversity of procedures in use the last few years and make for uniformity. Undoubtedly some of the discrepancies in the literature are due to the wide differences in methods used.

The curd tension instrument in use to the greatest extent at present is the American Curd-O-meter made by Heusser Instrument Company of Salt Lake City. This equipment has been found satisfactory if an automatic method of raising the curd receptacle against the knife is provided. The simplest means of accomplishing this is through the use of a small hydraulic lift which can be constructed easily by any sheet metal worker.

In 1936 the Submarine Signal Company, of Boston, developed an instrument with a knife similar to that employed by the Curd-O-meter except that it is suspended from a gauge floating in a column of mercury and moves

downward through the curd at an even rate, actuated by a motor. When properly used this instrument and the Curd-O-meter give closely agreeing results.

Within the last year, Chambers and Wolman (14, 87) have described a method of determining curd particle size when milk is coagulated in "artificial stomachs" under conditions arranged to simulate those in vivo. Their method calculates the curd surface of the coagulated milk as an index to its digestibility. This method, providing the conditions are what they should be, would seem to offer a more accurate gauge of the digestion characteristics of milk than curd tension, since the rate of gastric digestion and the rate of stomach clearance appear to be related to curd surface area (7, 22) or curd particle size (6, 26) rather than to curd toughness as such. More study is needed before this idea is accepted and perhaps some modifications and simplifications of the suggested technique would be desirable before the method is offered as being superior to that of curd tension. Chambers and Wolman find a general relationship between their "curd numbers" and curd tension as determined by the original Hill method. There are, however, some rather wide discrepancies in the case of certain modified milks.

NATURAL SOFT CURD MILK

Composition and Properties.—Normal, individual, cow's milk will vary in curd tension from about 15 grams to about 150 grams by the Hill method. Using the tentative method (19) or Miller's procedure (58), the range will be wider, soft curd milk giving about the same results but hard curd milk showing higher values (24, 58). While Hill originally suggested an upper limit of 20 grams (37) for soft curd milk, at present by common consent, milk with a tension under 30 grams (in a few cases 33 grams) is considered as soft curd.

Natural soft curd milk is found in all breeds of dairy cattle but predominates in the Holsteins, followed in order by the Ayrshires, Brown Swiss, Guernseys and Jerseys (2, 5, 22, 37, 39, 66). It is invariably low in total solids, solids-not-fat (particularly casein), fat, and probably ash (22, 26, 38, 59, 60, 83). Several studies have failed to indicate that there is any inherent qualitative difference between soft curd milk and hard curd milk or between the respective ingredient substances, the work of Weisberg *et al.* (83) being outstanding. It appears, therefore, that soft curd milk is not a different kind of milk but merely a milk low in solids and of high water content. The ingredient of milk most closely related to curd tension is casein (2, 22, 83). Doan and Welch (22) assert that curd tension is a linear function of the casein content within the limits of error of the Hill test and the data of Anderson, *et al.* (2) are even more definite on this point. Because of its dilute composition, soft curd milk is lower than hard curd milk in titratable acidity (22), buffer capacity (22, 60, 83),

energy value (26, 60) calcium and phosphorus content (2, 22, 83) and its rate of coagulation with rennin is retarded (40, 71). There appears to be no significant difference between the two types of milk with respect to: pH (22, 60, 71, 83), flocculation point of casein (22, 83), freezing point (22, 83), surface tension (22), and relative viscosity of the whey (83). Whether the proportions of the three different casein fractions found in milk by Svedberg, Carpenter and Carpenter (74) vary as between soft and hard curd milk is not known but has been suggested as a possible difference (83).

The curd tension of milk may be elevated by removing fat in the form of cream or lowered by adding cream (22, 35, 37, 71). Natural high fat milk, being richer in casein as well, usually has a high curd tension compared with natural low fat milk. The curd tension of milk may be lowered by increasing the pH artificially (22, 83) which makes the reaction less suitable for enzyme coagulation.

The opinion of Weisberg *et al.* (83) as to the mechanism in milk which influences and determines the curd character is probably correct and worth reiterating. They hold, that the colloidally dispersed phase differentiates a soft curd from a hard curd; that concentration and manner of dispersion of the fat, casein, and colloidal phosphates control curd character; that hard curd milk containing more numerous casein particles (and, therefore, coagulation centers) will form a more closely woven net-work on coagulation, resulting in less occlusion of the serum and a denser mass; that fat may contribute to the curd character by interrupting the growth of micellar casein threads, thereby, making a shorter grained texture; and that the degree of dispersion of the fat is as important as its concentration in affecting curd character. This view is compatable with the actions involved in reducing curd tension by various processes and modifications, if the necessity for calcium ions, to render the para caseinate insoluble, is stressed and if the effect of previous coagulation or denaturation of casein and its influence on enzyme action is considered.

Natural Variations in Curd Tension.—The curd tension of cows' milk, while shifting somewhat due to stage of lactation, season and other natural causes, is more or less an individual characteristic of the animal and persists from one lactation to another, at least to the extent that composition does not vary (17, 22, 36). Some investigators have not obtained data which would substantiate this statement (5, 66). There seems little doubt, however, that cows carefully selected for the low tension character of their milk, could be assembled and maintained as a herd without excessive turnover of members from one lactation period to another.

The curd tension of milk is high in the colostral period, drops to a low point in the second or third month of lactation, then slowly increases with the duration of lactation, reaching a high level when the milk flow becomes

small, and finally drops to zero when the properties of the milk become abnormal at the extreme end of the period (5, 17, 22, 35, 37, 60, 66). Season and atmospheric conditions affect curd tension in a parallel fashion to composition as would be expected (22, 37, 60). The curd tension is highest in November, December and January and lowest in May, June and July in most sections. Sudden and drastic changes in weather conditions also seem to influence curd character (36). In general it may be said that any natural influence which affects milk composition will be reflected in the curd tension.

Mastitis:—Sub-clinical mastitis infections (mild garget) of the udder cause a drop in the curd tension of the milk from the infected udder or quarters (2, 20, 31, 59, 71, 84), the amount varying with the degree of infection (32, 34, 35). This is very evident when milk from clean udder quarters is compared with milk from diseased quarters of the same cow. The decrease in curd tension is frequently sufficient to drop average milk into a soft curd classification (2, 31). Hansen, *et al.* (31) state that an infection caused by staphylococci does not affect curd tension but Anderson *et al.* (2) found that staphylococci infections had even greater effects than streptococcic, and in two cases of "coli-like" infection the curd tension was lowered to the greatest degree.

The cause of the decreased curd tension of mastitis milk appears to be due, primarily, to a lowered casein concentration (2, 22, 69, 70), although the higher pH of such milk is also probably a contributing factor (22). Anderson *et al.* (2) have further shown that a lower calcium and phosphorus content and particularly a change in the ratio of casein to calcium to phosphorus in mastitis milk is a significant influence. It should be noted that Dahlberg *et al.* (20) found little change in the curd tension of milk, as a result of sub-clinical mastitis, by the Hill or Miller procedures but noted a decrease when milk was coagulated with pepsin alone. The discrepancy appears to be due to the fact that their samples came from animals very mildly infected as indicated by the normal casein content and the very slight change in other constituents. It is certainly possible to obtain milk from diseased udders which is normal macroscopically and yet will show the definite changes in composition and properties that have been noted by most investigators. In fact Rowland and Zein-El-Dine (69) have proposed a test for mastitis based on the ratio of casein nitrogen to total nitrogen.

In view of the relationship between udder infections and low curd tension values of milk, it is essential in the commercial production and sale of natural soft curd milk to take unusual precautions in selecting uninfected animals when assembling a herd and in keeping the herd free from mastitis during milk production (2, 22, 31).

MODIFIED AND PROCESSED SOFT CURD MILK

Physicians have practiced milk modification for many years in an effort to find suitable substitutes for mother's milk in the artificial feeding of infants. The literature dealing with these efforts and the results obtained is much too extensive to review here. Let it suffice to say that, as Brennemann early pointed out (6), practically all of the successful modifications are effective primarily through their ability to alter the curd character of the coagulum obtained in the stomach; in other words to cause small curd particle size (33). This view has been substantiated in later studies by Lynch (50) and Jeans and Stearns (43), even for acidulated milk.

The boiling of fresh milk for infant use is widely practiced at present and it is the opinion of the Council on Foods of the A. M. A. that "All cow's milk used for the preparation of infant feeding mixtures should be boiled" (18). In addition to boiling or sometimes as a substitute for boiling, such modifications as: dilution; acidification; alkalization; the addition of cereals, lime water and certain colloids; and such processes as homogenization, base-exchange treatment, enzyme alteration or some combination of these, have their advocates.

Only such modifications and processes as can readily be used by the milk dealer in preparing a suitable milk basis for infant formulas will be discussed in this review.

Dilution.—When water or milk serum is added to milk the curd tension is decreased (22, 26, 83) more or less in proportion to the degree of dilution (22). Brennemann (6) found that dilution resulted in smaller, more porous curds in the stomach but Wolman (87) states that while dilution reduces curd tension, it does not alter the curd particle size in the "artificial stomach."

Heat Treatment.—The effect on curd tension of heating milk depends entirely on the temperature used and the time of exposure. Pasteurization has a negligible effect (5, 11, 22, 76). Heating at 160° F. for 30 minutes causes a distinct lowering of the tension (11), about on a par with a flash treatment at 180° F. (11, 22), while a 30 minute treatment at 180° F. or boiling for 5 minutes decreases the tension markedly, usually sufficient to render average milk (50–60 grams) definitely soft curd (under 30 grams) (11, 22, 76). Autoclaved milk and evaporated milk frequently exhibit no curd tension (22, 37, 61).

The effect of previous heating of milk on its reaction to rennin and pepsin has never been satisfactorily explained due to the obvious complexity of the changes occurring. It seems likely that the calcium ion concentration is decreased, the electrostatic charge carried by the casein micelles increased, some albumin rendered insoluble and the protein itself denatured (67), while at the higher temperatures (autoclaving and sterilizing) an actual heat coagulation of extreme fineness may also be produced (46) which renders the casein more or less immune to enzyme coagulation.

Acidification.—As the pH of milk is reduced from the normal (6.4 to 6.7) a toughening of the enzyme curd is observed until the pH drops under approximately 5.9. From this point down to the isoelectric point (pH 4.7) the curd tension decreases (22). This decrease is undoubtedly due to the progressive agglomeration or coagulation of casein in the acid form which interferes with the formation of the para casein curd induced by enzyme action.

It should be noted that the above observations do not apply when the tension is measured by the Hill test (36) using calcium chloride in the coagulant. In the latter case a maximum curd tension is obtained at a considerably lower pH (5.2 to 5.6) (22, 83).

The usual method of acidifying milk for infant use is to add acid (hydrochloric, citric, lactic, acetic, lemon juice, sauerkraut juice, etc.) to such a degree that a fine acid coagulation occurs in cold agitated milk. Little or no enzyme curd will be obtained with such pre-coagulated milk. The use of acid milk has been advocated by many pediatricians, chiefly as a result of the publications of Marriott *et al.* (53, 54, 55, 56). Gonce and Templeton (44) suggest citric acid as being superior for acidifying infant milk.

Homogenization.—When whole milk is homogenized the enzyme curd is rendered considerably softer (5, 11, 22, 71, 75, 76, 79, 82, 85). Skim-milk is not so affected (12, 22, 71, 78) which lends support to Weisberg's view concerning the relation of the degree of fat dispersion to curd structure (83).

The effects of homogenization vary with the curd tension of the milk processed, the fat content, the pressure used, and the auxiliary heat treatment. Hard curd milk is softened to a greater degree than soft curd milk although usually not sufficiently to place it in a soft curd classification (5, 11, 22, 75). High fat milk requires higher pressure of homogenization to bring about maximum decreases in curd tension (22, 44). Pressures over 2500–3000 pounds accomplish little (11, 22, 76) with average milk but under this point the tension falls as the pressure is increased, although not proportionately (5, 11, 22, 75, 76). Two stage processing and dual homogenization appear to have little effect not noted with comparable single valve treatment (17, 75, 76).

The temperature treatment of the milk before and during homogenization exercises considerable influence on the results. A greater effect, naturally, is noted when milk is processed at high temperatures due to the additive action of the heat and the homogenization (11, 22, 44, 76) but at very high temperatures (180° F. to boiling) homogenization produces little or no additional lowering of the tension under what is accomplished by the heat alone (44).

Differences between the preheating or pasteurizing temperatures and homogenizing temperatures exercise an influence divorced from the heat

effect itself. Curd tension is reduced to a greater degree when the milk is cooled down to 100°–120° F. before processing rather than to homogenize at the preheating or pasteurizing temperature (11, 22, 85). The greatest reduction appears to be obtained when the temperature range through which the milk is cooled is greatest (22).

All of the above effects have been noted with high pressure, piston machines. At present there are on the market and in use low pressure, rotary homogenizers, which pressure for pressure, seem to have slightly more effect in reducing the curd tension of milk than the piston machines (23). Since their pressures are limited to less than 1000 pounds, they are not capable of producing the amount of change possible with piston machines at 3000 pounds pressure (23, 77).

The curd tension of milk may also be lowered and the product homogenized by conducting it, in a thin layer, over a diaphragm, oscillating at high frequency (12). This process developed by the Submarine Signal Company apparently produces the same general results as are obtained with low pressure homogenization but without any appreciable pressure (12, 13, 23, 28, 87). The method is being used commercially in a few places, the product being known as "sonized" homogenized milk. The amount of experimental work carried on with this process has been rather limited.

Any explanation of the effect of homogenization on the curd tension of milk hinges, without question, on the increased dispersion of the fat which introduces more points of weakness in the coagulum, in line with Weisberg's theory (83). The increase in adsorbed protein may also be a factor since it is quite possible that this membrane protein may not participate in the coagulation in the same manner as it would in the motile state. It has also been noted that the curd from homogenized milk is more highly hydrated than from unhomogenized. This may be a factor in softening the coagulum (29). Again, homogenization may displace some of the normal phospholipide-protein complex from the fat globule surface, releasing it into the plasma in a manner similar to churning. This would affect the tension of the curd (63). Finally, recent work (52) has shown that homogenization raises the freezing point of milk, indicating an adsorption of solutes some of which may be calcium. This would effect the rigidity of the peptic or rennin coagulum under the conditions of the determination.

Base Exchange Treatment.—A method was devised a few years ago (48, 49) for retarding enzyme coagulation of milk by the removal of a considerable portion of the soluble calcium. This is a base-exchange process wherein acidified milk (citric acid) is percolated through a zeolite bed, giving up calcium and phosphorus (about 20 per cent) in exchange for sodium and potassium. By properly regulating the conditions, milk with normal pH and normal ratios of calcium to phosphorus and sodium to

potassium can be obtained. Such milk is low in ionized calcium and will usually exhibit a curd tension between zero and 10 grams by the Miller technique. Where the Hill test is used no reduction of curd tension will be evident because of the calcium of the reagent. This product is being marketed in several cities under the name "Sof-Kurd" milk.

One of the frequently voiced objections to "Sof-Kurd" milk is the removal of nutrient minerals, the value of which have been stressed for years and upon which much of the nutritional excellence of milk has been based. However, Hess, Poncher and Woodward (34) in a study using one infant show that the retention of calcium was higher on base-exchange milk than on normal milk. This evidence is hardly sufficient to be conclusive and the subject needs more study.

Another objection to base-exchange milk is the fact that the product is sensitive to temperature changes. Boiling (48) or even heating to temperatures over 100° F., if held for an appreciable time, (29) causes a readjustment of the ionic equilibrium such that curd tension values are considerably increased. The action is reversible and returns to the original value on cooling and holding at low temperature (29, 48). The product is therefore somewhat temperamental and the usual procedures for preparing infant feedings may possibly give rise to variable fluctuations in the curd character of this milk in the stomach.

Enzyme Treatment.—Conquest, Turner and Reynolds (16) have proposed a method of reducing the curd tension of milk which employs a period of incubation with an extract of hog pancreas followed by prompt pasteurization. This method is too new to evaluate as yet but seems to offer possibilities. The use of trypsin in similar fashion has been studied by Flora (29) who was able to obtain decreases in curd tension approximately as great as are possible with homogenization, without appreciably affecting the flavor of the milk although, in some cases, the creaming ability was altered.

Treatment of this type is in the nature of a pre-coagulation possibly combined with some denaturation and decomposition of the protein and the effect on a subsequent gastric coagulation is probably not dissimilar from that obtained with acidification, renneting, or high heat treatment.

Agitation.—Lundstedt (47) suggested a method of lowering the curd tension of milk by agitation and churning at low temperature. He claimed that the lecithin of the fat globule membrane was removed and adsorbed by the casein thereby modifying the coagulation properties. Palmer and Tarassuk (63) were unable to duplicate Lundstedt's results on agitation but they did show that when the fat globule membrane (phospholipide-protein complex) is removed from the globule in the process of churning, the curd tension of the resultant buttermilk is considerably lowered.

THE DIGESTIBILITY OF SOFT CURD MILK

The value of soft curd milk, or any modified milk, for infant or invalid use rests on its digestibility characteristics. The curd tension value has been offered as an index of digestibility but has not been definitely proven a satisfactory one. Neither has it been proven definitely unsatisfactory. The size of curd particles formed when milk is coagulated by gastric enzymes is believed to be related to ease of digestion or rate of stomach clearance. Until recently no method of measuring curd particle size was used other than regurgitation of ingested milk and examination of the curds obtained. This index, therefore, also awaits definite substantiation as a measure of milk digestibility. In vitro methods of determining the digestion characteristics of milk have been used to a considerable extent. They are useful in obtaining positive results and in studying phases of the problem difficult or impossible to follow in vivo but procedures have varied so greatly that it is frequently difficult to evaluate the results obtained. In vitro methods which simulate conditions and changes occurring during infant digestion should be productive of useful information but they are always open to the criticism that the conditions are artificial and therefore inconclusive. Methods of rating digestibility utilizing the digestive systems of animals may or may not be more indicative than in vitro methods, depending on the accuracy with which results can be noted or measured and on the similarity existing between the digestive system of the animal and the human infant. In the last analysis any index of digestion must be substantiated clinically with infants; otherwise its meaning and its value are uncertain.

Up to the present only a few studies have produced results which make it possible to accurately evaluate any of the indices discussed and still fewer are available to indicate the usefulness of the more recently suggested methods of processing milk to render it a more suitable base for infant formulas.

Observations with Humans.—It is common knowledge that evaporated milk, boiled milk and acidified milk have proven satisfactory as substitutes for breast milk in infant feeding (8, 18, 57, 65). Although all of these milks have very low curd tension values, their success has generally been ascribed to the fineness of the coagulum found in the stomach following their ingestion (8, 43, 50, 64). There seems to be little doubt but that boiled, evaporated or acidified milks are evacuated from the human stomach more rapidly than similar untreated milk (6, 22, 29, 51, 72). This has also been found true with animals as will be indicated later. Ogilvie and Peden, (62) however, found little difference between boiled and raw milk in infants, where stomach tubes were used to sample the gastric contents and Davidson, *et al.* (21) was not able to find appreciable differences between ordinary milk and several types of modified milk (including evapo-

rated) when fed to adults with barium and the rate of stomach emptying noted by means of a fluoroscope. It might be pointed out, however, that Brennemann (6) found in numerous cases that a stomach tube was inadequate for sampling gastric contents and it has never been shown that the admixture of barium sulfate does not greatly alter the characteristics of the milk coagulum in the stomach.

In case studies and clinical observations reported by Hill and others, (4, 17, 36, 37, 39) natural soft curd milk is described as being very satisfactory for infant use, overcoming digestion disturbances such as vomiting, regurgitation, colic and undigested protein in the stools. Elias (25) and Morris and Richardson (60), on the other hand, failed to note any decided advantages for natural soft curd milk over the usual satisfactory formulas. The results reported by these workers are not too indicative inasmuch as Elias' babies ranged up to 2 years in age and the boiled certified milk utilized by Morris and Richardson averaged lower in curd tension than the soft curd milk which was fed raw in most cases. Data presented by the latter workers indicate that their infants on soft curd milk did as well as those on evaporated milk.

Several investigators have noted that natural milk of low tension gives rise to smaller and softer curds in the stomachs of infants and adults (3, 17, 22, 25) as judged by regurgitation tests or the use of stomach pumps. Anthony (3) found the same to be true of homogenized milk but not of base-exchange treated milk.

Homogenized milk and most of the other types of processed milk have been insufficiently studied with humans to make conclusions possible. Wolman (87) states, apparently as a result of in vitro studies, that adequately homogenized milk is an excellent foundation for infant formulas and Wilcox (86) reports, as a result of Roentgenological studies with adults, that homogenized milk leaves the stomach in advance of soft curd milk and average milk.

The common conception that the fat of homogenized milk is more assimilable by infants because of its greater dispersion seems unfounded in view of the studies of Holt and co-workers (41).

Rogers, *et al.* (68) found base-exchange treated milk to be a good complemental food for new born infants, better gains and fewer losses resulting than where untreated milk was used and, as previously noted, one very limited study (34) indicated that the lack of calcium and phosphorus in base-exchange treated milk does not impair its nutritive value since the remaining minerals are assimilated to a greater degree.

Observations with Animals.—Digestion comparisons have been made with soft curd milk, boiled milk, acidified milk, evaporated milk and a few of the other types of modified milk using such animals as dogs, calves and rats. Some of the results obtained appear quite indicative but there

have been far too few such studies to warrant placing much weight on them, particularly since the digestive apparatus of calves is quite dissimilar from humans and the stomachs of adult dogs appear not to coagulate milk normally (33).

Working with dogs, Espe and Dye (26) concluded that soft curd milk leaves the stomach quicker than normal or hard curd milk. The same conclusion has been reached in other studies using calves (22, 27, 61) and rats (22) and for boiled milk and whole milk as compared with unboiled milk and skimmilk respectively (27, 61). It has also been shown that soft curd milk, buttermilk and evaporated milk travel farther and disappear more rapidly in the intestines of rats than does hard curd milk (22). Hess and co-workers (33) found that modified milks (boiled and acidified) form loose, small curds in the stomachs of puppies, whereas raw and pasteurized milks form large tough coagula. Milk treated with enzymes of the hog pancreas to reduce the curd tension and fed to calves was observed by Conquest, *et al.* (16) to have an increased rate of stomach clearance compared with normal untreated milk.

In some recent studies, Flora (29) observed that natural untreated milk is digested by rats at a rate roughly proportional to the curd tension but that homogenized milk (by whatever method processed) and to a much lesser degree, base-exchange treated milk digest at a slower rate than the respective curd tensions would seem to indicate.

In Vitro Studies.—It is difficult to decide how much confidence to place in the methods which have been devised for measuring the digestibility of milk by laboratory means inasmuch as clinical substantiation of the results is usually lacking and inasmuch as little information has been obtained regarding the actual conditions under which milk coagulates in the infant stomach. Marriott and Davidson (54) present the following data regarding the pH of the infant stomach at the height of digestion (2 hours after feeding).

	Breast Fed	*Cows Milk*	*Acid Milk*
Normal	3.75	5.10	3.71
Abnormal	4.74	5.35	4.10

These values are much higher than obtain in adult digestion (32) and since it has been shown that cows milk is coagulated in adults at a pH of 5.9 or higher 10 minutes after ingesting one pint of milk on an empty stomach, (22) it seems reasonable to believe that coagulation in the infant stomach takes place at a pH at least this high and perhaps higher.

A "rennin type" curd is obtained when milk is coagulated with peptic enzymes at a pH of 6.0 or above. Between pH 5.0 and pH 6.0 the coagulum appears to be a mixture of the acid and rennin types, while at a pH of less than 5.0 the curd is predominately acid in type. The character of the coagulum (curd tension and curd particle size) will vary with the

reaction at which it forms (22, 42) as will also its digestion properties (42). It therefore appears evident that, in methods for following rates of digestion in vitro, the conditions under which the milk is coagulated are of prime importance and should simulate the conditions in the infant stomach as closely as possible. Furthermore it is the writers belief that the conditions should conform to those found in the new born rather than to those existing in babies six months or over in age. It seems axiomatic that any type of milk which proves satisfactory in new born babies will cause no difficulties with older ones. It is in the very young that most difficulties with cows' milk are experienced.

Hess *et al.* (33), using an in vitro method set up to simulate stomach conditions concluded that, while curd particle size is a most important factor in digestion, other influences are also of moment. They found that boiling milk lowers the soluble nitrogen content as does also acidification, but both of these factors favor peptic digestion. This in itself is evidence that the physical character of the curd is of first importance and overshadows other lesser effects. Schultz and Fetter (73) found that milk containing rennin (Junket) is acted upon more rapidly by pepsin. Wallen-Lawrence and Koch (80) observed that heated milks (boiled and evaporated) are attacked more rapidly by trypsin than unheated milk and explained this as being the result of the destruction (by heat) of a labile trypsin inhibitor found in the whey of raw milk. Doan and Welch (22) showed that soft curd milk digests faster at any pH than does hard curd milk and that peptic digestion appears to be a peripheral process as far as nitrogen break down is concerned. Lear and Skaggs (45) found that natural soft curd milk has superior digestion qualities to normal milk and that boiled milk and homogenized milk have inferior qualities. Their results with boiled milk were due to the fact that soluble nitrogen was taken as an index of stomach digestibility and, as has been indicated (33), boiling itself lowers the soluble nitrogen. Chambers and Wolman (14) and Wolman (87) have reported enhanced digestibility for homogenized milk, heated milk, natural soft curd milk and various types of modified milk. Their method made use of thin walled rubber bags ("artificial stomachs"), in which a type of agitation more nearly approaching peristalsis was obtained. Their measure of digestibility was the curd particle size or the curd surface area which resulted when the various milk samples were treated under uniform conditions to simulate coagulation and the first stages of digestion in the stomach. Their results indicate that curd tension correlates quite satisfactorily with curd particle size except with a few unusual types of modified milk. A pH of 4.5 which was used in these studies might be criticized as being too low, particularly when used as the coagulation reaction.

Studies recently reported by Hull (42) show that homogenized milk does not digest any more easily than unhomogenized milk but that evaporated milk, base-exchange treated milk and boiled milk do have enhanced digestion qualities. His results indicate that the pH at which the curd is formed has a very definite influence on the curd particle size and hence on digestibility. At the lower pH levels (5.2–5.7) the curd is less adhesive and in smaller aggregates and the breakdown is more rapid than at the higher levels (5.9–6.4). Flora's (29) work substantiates that of Hull, in many respects, although in the in vitro method used, tryptic digestion followed peptic and the results obtained were checked utilizing rats. He concludes that homogenized milk digests no better than unhomogenized, that curd tension is not an accurate index of digestibility with this type of milk or with base-exchange treated milk, that enzyme treated milk shows good peptic digestion characteristics and that any milk to be highly satisfactory as a base for infant formulas should have a curd tension of zero. In addition Flora noted increased tryptic activity with the heated milks (boiled and evaporated) in line with the findings of Wallen-Lawrence and Koch (80).

The available information on the digestibility of natural and processed or modified soft curd milk is inadequate to be conclusive. In some respects it is conflicting. There seems little doubt but that natural soft curd milk is more suitable for infant feeding than normal or hard curd milk but whether it is sufficiently more digestible to warrant its production is questionable since it does not seem to offer any definite advantages over evaporated milk, acidified milk and perhaps most boiled milk.

Homogenized milk (including sonized) has not reacted very favorably in some in vitro studies so that until further studies are made and particularly until careful clinical comparisons are available little can be offered in support of it. Base-exchange treated milk also needs further substantiation as an entirely satisfactory infant food. Present information would indicate that it is probably in a class with natural soft curd milk in that it seems to be more digestible than normal milk but not so digestible as evaporated and acidified milk.

Enzyme treated milk has been studied even less than the others. Results obtained by one or two workers indicate that it may have possibilities in infant feeding if and when a satisfactory method of preparing it is developed.

Much doubt has been cast on the curd tension value of milk as a satisfactory index of digestibility. It is the writer's opinion that the *size* of curd particles obtained in peptic coagulation under conditions of agitation and acidity closely approximating those existing in the stomachs of young infants would be a more suitable index than the *toughness* of the curd formed without any agitation. However, the pH at which coagulation is

to be accomplished would be a factor needing substantiation and one to be accurately controlled. Observations on this point with infants are lacking.

In conclusion it should be emphasized that, at present, none of the suggested methods of preparing a fresh fluid milk for pediatric purposes appears to be sufficiently satisfactory. At least evidence in their favor is too meagre or too fallible to constitute definite proof of their sufficiency. Instead of being content to promote the use of a half-satisfactory product or a product only half substantiated, the milk industry should redouble its efforts to develop a type of fresh cow's milk which will meet every requirement of the human infant or to thoroughly prove the excellence of existing types in a manner acceptable to pediatricians.

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American Dairy Science Association Announcements

RESULTS OF ELECTION

The results of the election of officers on October 1 were as follows:

Vice President: E. S. Guthrie, Cornell University, Ithaca, N. Y.

Directors to serve for three years each:

J. W. Linn, College of Agriculture, Manhattan, Kansas
M. E. Parker, Beatrice Creamery Co.,
1526 South State Street, Chicago Illinois

ANNUAL MEETING AT IDAHO AND WASHINGTON, WEEK OF JUNE 26, 1939

Our next annual meeting is to be held the week of June 26, in Moscow, Idaho, and Pullman, Washington. Will you please inform the secretary if you are interested to go by train and if so, would you use Pullman or Tourist Pullman beyond Chicago? A card stating your preference will in no way obligate you for the trip. This is merely to find out if it is worth turning over to the railroads who will close any contract if made. If enough interest is shown, we may arrange to have a special car or train so that you may go from the East to the meeting together.

	New York	Washington	Columbus	Chicago
Rail Fares Using Pullman	$128.40	$120.50	$94.20	$76.05
" " " Tourist Pullman beyond Chicago	118.45	110.55	74.25	66.10
Pullman Fares	20.00	19.50	16.50	14.00
" " Using Tourist Pullman beyond Chicago	13.50	13.00	10.00	7.50

A REVIEW ARTICLE

Beginning with the October issue, the editor has invited authorities to write on a specific subject. From six to twelve of these review articles will appear each year. In the October issue, Mr. C. J. Babcock has covered the subject of feed flavors in milk and milk products. We believe these review articles will be a great asset to the JOURNAL.

ASSOCIATION NEWS

Upon receipt of your JOURNAL will you please look for Association announcements? They will be found immediately preceding the abstracts.

Your officers will appreciate suggestions and criticisms in operating the Association, publishing the JOURNAL, etc.

We should appreciate your comment regarding the exhibit displayed at the National Dairy Show and the Dairy Industries Exposition.

BORDEN AWARD

Have you anyone in mind to be nominated for the Borden Award? These committees will no doubt be asking for nominations in the immediate future.

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T. S. SUTTON, Editor
Columbus, Ohio

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SPECIAL PUBLICATIONS

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Prussian Dairy Research Institute, Kiel, Germany

State Agricultural Colleges and Experiment Stations

The Royal Technical College, Copenhagen, Denmark

United States Department of Agriculture

ABSTRACTS OF LITERATURE

BACTERIOLOGY

519. A Study of Comparative Methods and Media Used in Microscopical Examination of Creamery Butter. I. Yeast and Mold Counts. G. W. SHADWICK, Beatrice Creamery Co., Chicago, Ill. Food Research *3*, 3, 287, May–June, 1938.

This paper presents the results of a comparative study of yeast and mold counts for salted and unsalted butters using as culture media freshly prepared potato-dextrose agar and the dehydrated potato-dextrose, malt, peptonized-milk, whey, and wort agars prepared by the Difco Laboratories.

F.J.D.

520. Heat Resistance Studied on Spores of Putrefactive Anaerobes in Relation to Determinations of Safe Processes for Canned Foods. C. T. TOWNSEND AND J. R. ESTY, Univ. of Calif., Berkeley, Calif., AND F. C. BASELT, American Can Co., New York City. Food Research, *3*, 3, 323, May–June, 1938.

Thermal death curves for *Cl. botulinum* in neutral phosphate media and in vegetables and milk are different. Data are presented from which safe temperatures and time intervals for sterilization may be chosen.

F.J.D.

521. The Respiration of the Rod-Shaped Lactic Acid Bacteria. P. ARNE HANSEN, Royal Tech. College, Copenhagen. Zentr. Bakt. II, *98*, 289–297, 1938.

The rate of respiration of 12 strains of lactic acid bacteria of known origin has been studied. Species of the genera Thermobacterium and Streptobacterium show very low rate of respiration and are not inhibited by hydrocyanic acid, while the genus Microbacterium gives high values and the rate of respiration is considerably decreased by HCN. It is recommended to consult quantitative respiration experiments in taxonomic work.

J.C.M.

522. Counting Bacteria. S. ORLA-JENSEN AND G. FAULENBORG, Royal Tech. College, Copenhagen. Zentr. Bakt. II, *97*, 387–389, 1938.

Comparative counts of bacteria were carried out on milk samples each of which were divided in four parts and treated as follows: one was left raw; the second pasteurized at 63° C for 30 min.; the third heated at 80° C for 2 min.; the fourth sterilized. Both plate counts and direct microscopic

counts were used. In the latter case the individual cells as well as groups of cells were separately recorded. Observations were carried out over a period of 10 days, samples being removed at once and at intervals, temperature of incubation was 5° C., chloroform was added. The dead bacteria present gradually disappeared, after two days in the sterilized milk; after 8 days in the milk heated to 80° C. The simultaneous use of plate and direct counts is advocated. J.C.M.

523. The Hemolytic Streptococci of Milk. C. F. NIVEN, Dept. of Dairy Industry, Cornell Univ., Ithaca, N. Y. Milk Dealer, *27*, 11, 64–67, August, 1938.

A total of 313 samples of commercial milk, 68 raw and 245 pasteurized, were examined for hemolytic streptococci. Narrow-zone hemolytic types in blood agar, the most typical form of *Streptococcus mastitidis*, were not considered. Only 8.5 per cent of the pasteurized samples contained hemolytic streptococci, as here defined, whereas broad-zone hemolytic types were obtained from 18 per cent of the raw samples.

The cultures isolated were studied serologically and physiologically, and, on the basis of these results, six groups or species were recognized: *Streptococcus mastitidis* (Lancefield group B), the "animal pyogenes" (Lancefield group C), *Streptococcus durans* (Lancefield group D), *Streptococcus zymogenes* (Lancefield group D), and two other types which differ serologically and physiologically from any adequately described species of streptococcus.

The prevailing types of hemolytic streptococci in raw milk are *Streptococcus mastitidis* and the "animal pyogenes"; the most common forms in pasteurized milk are *Streptococcus durans* and *Streptococcus zymogenes*. C.J.B.

524. The Phenomenon of the Extensibility of Ferments. W. M. BOGDANOW, Institute for Scientific Research in the Dairy Industry, Leningrad, U.S.S.R. Le Lait *18*, 176, 576–582 (June, 1938).

An organism is described which causes the development of a stringy condition in milk. A stable symbiosis possesses high proteolytic activity. During prolonged incubation of the ferment, the acidity gradually decreases and a strong peptonization of the albumin takes place. The combination of organisms described is acceptable for cheese making. A.H.J.

BREEDING

525. A Factor in Breeding Efficiency of Dairy Cattle. HOWARD CLAPP. Proc. Amer. Soc. Animal Prod. *30*, 259–265, 1937.

At this large breeding establishment (Pabst Farm) it was found that the mean interval between calving and the first oestrum following was 46.4

days for cows milked twice daily, 69.4 days for cows milked four times daily (test cows), and 71.8 days for cows nursing calves. Among the group on test there was no difference in interval due to the month of freshening, but in the group not on test there was a slight significant difference, the shortest intervals occurring in December to February freshening cows. G.C.W.

Other abstracts of interest are 542, 554, and 560.

BUTTER

526. The Spreading Capacity of Butter. G. W. Scott Blair, National Institute for Research in Dairying, Univ. of Reading, Shinfield, Nr. Reading, England. Jour. of Dairy Research *9*, 208–214, 1938.

An instrument designed to study the rheological properties of butter is described. The time required for a given weight to compress a cylinder of butter through a given distance is used to calculate the viscosity of the butter. S.T.C.

527. Studies of the Keeping Quality of Butter in Cold Storage. O. R. Overman, O. F. Garrett, and H. A. Ruehe. Ill. Agric. Exper. Sta. Bull. 446, Sept., 1938.

"The purpose of this investigation was to study butters of differing quality and from differently treated creams during extended periods of storage at customary storage temperatures in order to determine the influence of various factors upon the keeping quality of the butter, and especially to determine whether correlation exists between the keeping quality of butter and the results obtained by a laboratory examination of the fat."

A review of the literature and bibliography of sixty-six references is given.

During the investigation reported the behavior in cold storage of thirty-six different butters ranging in quality from poor to excellent was studied. The butters were stored in 3 pound packages, 10 to 12 packages of each butter being available. The butters were subjected to laboratory examination at definite intervals.

The examination included scoring of the butter and the determinations on the filtered fat of index of refraction, iodine absorption number, saponification number, soluble acids, insoluble acids, free-fatty acids, acetyl value, Reichert-Meissl, Polenske, and Jensen-Kirschner numbers, the pH of the serum and the computation of the mean molecular weights of the fats. The rates of oxygen absorption of the fats were determined also.

The following observations and conclusions were made as a result of this study:

1. The judge's score of a butter, although a statement of quality at the time of scoring does not give any indication of its keeping quality.

2. The particular chemical and physical constants determined do not show correlation with keeping quality.

3. The induction periods and the rates of oxidation vary so irregularly that there is no evidence of any relation of these to keeping quality.

4. Butter made from sweet cream scored higher and held its score better in storage than butter made from the same cream after ripening with starter and partial neutralization, and the latter was correspondingly better than butter made from the same cream after spontaneous souring and neutralization to the same percentage of acidity.

5. Different neutralizers used to reduce the acidity of separate lots of the same cream to approximately the same percentage of acidity did not affect the initial score or the keeping in storage.

6. Butter from cream ripened with starter to .44 per cent acidity and churned without neutralization scored higher and held its score better in storage than did butter from the same cream after it was ripened with starter to .61 per cent acidity and churned without neutralization. The latter was correspondingly better than butter churned from the same cream without neutralization after ripening with starter to .82 per cent acidity.

7. Overneutralization of cream produced a butter with low initial score and poor keeping quality.

8. Butter churned from sweet cream and salted scored slightly higher but lost score more rapidly than unsalted butter from the same cream.

9. The butters which were given the highest initial scores and held their scores best of all those studied in these investigations were churned from fresh sweet cream separated from fresh sweet whole milk. These butters were not salted and were of salable quality after about two years in storage.

O.R.O.

528. Treatment and Transformation of Milk, Improvement of Quality. The Aroma of Butter. W. Mohr, Kiel, Germany. Le Lait *18*, 177, 743–758 (July, August, 1938).

The principle aromatic substance in butter is diacetyl. The formation of diacetyl is due to the action of bacteria on citric acid. Formation of diacetyl and acetyl methyl carbinol are related but the mechanism of their formation is not definitely known. Among the problems in this connection are whether both substances are formed simultaneously or whether diacetyl is formed from the oxidation of acetyl methyl carbinol and if such is the case, by what mechanism, or if diacetyl is produced simply from acetaldehyde in the course of oxidation with subsequent condensation. Increasing acidity and aeration favor the production of diacetyl. High temperatures at the time of proper acidity, notably the temperature optimum for the growth of bacteria are not favorable for the production of

diacetyl. Diacetyl is formed more rapidly between 12° C. (53.6° F.) and 16° C. (60.8° F.) or between 17° C. (62.6° F.) and 21° C. (67.8° F.) with cooling of the culture to 10° C. (50° F.) when the acidity has increased to 23° S.H. The conditions that apply to the formation of diacetyl and acetyl methyl carbinol in cultures apply equally in the cream used for butter making. During churning the content of diacetyl and acetyl methyl carbinol increases and is significantly higher in the buttermilk than in the cream. The butter contains about 1/4 the diacetyl and 1/15 to 1/16 the acetyl methyl carbinol found in the ripened cream. The diacetyl and acetyl methyl carbinol are found distributed throughout the butter in the aqueous phase of the serum and not at all in the fatty phase. The washing of the butter eliminates a considerable part of the diacetyl and acetyl methyl carbinol. At ordinary temperature and for short storage periods, *i.e.*, at 10° C. (50° F.) and up to 4 days, there results an increase in diacetyl. Within 10 to 12 days, however, the diacetyl decreases. On storage at low temperature 0° to 10° C. (32° F. to 14° F.) the content of diacetyl does not undergo change.

Butter made from sweet cream contains only very small amounts of diacetyl, nor is diacetyl formed during prolonged storage for as long as 6 months. Methods of determining diacetyl and acetyl methyl carbinol are discussed. It is emphasized that differences in methods and technique account for the variation in results obtained by different investigators and that this makes it difficult to interpret results from different laboratories. A rapid practical method that will give reliable results and that will be applicable both to research and control laboratories is needed.

A.H.J.

529. Keeping Quality of Butter. JOHANNES JENSEN AND W. RITTER, Aabenraa, Denmark, and Berne-Liebefeld, Switzerland. Le Lait *18*, 177, 758–773 (July, August, 1938).

Fishy flavor in butter is due to the formation of tri methylamine originating from lecithin as a result of hydrolysis and oxidation. The oxidation is markedly accelerated by the presence of small amounts of metals, particularly iron and copper. Copper is about 13 times as effective as iron in catalysing the oxidation. Pasteurization at 90° C. (194° F.) of the cream from which the butter is made operates to prevent the development of the fish flavor. This is due in part to destruction of bacteria and probably partly to antioxidants formed at the high pasteurization temperature. Some types of bacteria in butter reduce the rate of fishy flavor development in butter by consuming the oxygen contained in the butter. The acidity of the cream from which the butter was churned is important in controlling the keeping quality and should not vary from the desired acidity of 23 to 25 S.H. Stored butter derived from cream of acidity 20 S.H. has a tendency to mold, while butter derived from cream of acidity more than 29

S.H. becomes rancid prematurely. Butter oil prepared by the boiling method is a satisfactory means of storing butterfat for considerable periods with less danger of off flavor developing than if butter itself is stored. The butter fat prepared by this method, however, possesses flavors imparted to it by the cooking process while the natural aroma of the original butter may have been driven off. Methods of packaging butter to prevent the development of off flavors is discussed. Light is the chief factor involved in off flavor development in packaged butter. Protection from light by black paper or metal foil or papers containing materials that absorb ultra violet are described. Variations in the chemical characteristics of butter take place from season to season as a result of change in the feed of the cows. Thus the average saponification number was found to be 232 from December to February and 222 in summer. The Reichert-Meissl-Vollny number had a value of 33 in winter and 29 in summer. The Polenski number had an average value of 5 in winter and 3 in summer. The xylol index averaged 23 from February to April and about 20 in July and August. The index of refraction was 1.4537 in winter and increased to 1.4555 in summer. The iodine number increased from 35 in January to 41 in summer. The effects of individual feeds and feeding régimes on the chemical constants of the butterfats are discussed and data presented. A relation between the fat content of the milk and the iodine number of the fat is observed. If the fat content of the milk increases, the iodine number of the fat decreases. Butter of an iodine number of 28.5 to 34.5 is, from the physical point of view, considered to be satisfactorily conditioned. Butter with an iodine number above 34.5 is considered too soft and below 28.5 it is too hard and brittle. A.H.J.

Other abstracts of interest are 519 and 559.

CHEESE

530. The Calcium and Phosphorus Contents of Some Types of British Cheese at Various Stages during Manufacture and Ripening. E. C. V. Mattick, National Institute for Research in Dairying, Univ. of Reading, Shinfield, Nr. Reading, England. Jour. of Dairy Research *9*, 233–241, 1938.

The calcium and phosphorus contents at various stages in the manufacture and during ripening of Cheddar, Cheshire, Leicester, Lancashire and Stilton cheese were determined. There was little difference in the values of the hard pressed varieties, however, Stilton cheese contained much less calcium and considerably less phosphorus than the hard pressed cheese. From about 50 to 60 per cent of the original calcium of the milk was left in the hard pressed cheese after 8 months, and only about 7 per cent in Stilton. S.T.C.

531. The Rôle of Bacteria in Milk Destined for the Fabrication of Gruyère or Emmental Cheese. W. DORNER, Agronomic Engineer for the Federal Institution of the Dairy Industry, Liebefeld, Switzerland. Le Lait *18*, 175, 449–455 (May, 1938).

The numbers of bacteria play a very important rôle in the preparation and ripening of cheese. Harmful bacteria are more harmful when they are more numerous, and useful bacteria may be harmful when they are too numerous. *Bacterium amylobacter* causes a swelling up of the cheese and *Bacterium proteolyticum* causes a secondary offensive fermentation. With the exception of *Bacterium coli* and *aerogenes* when they come from mastitis, the pathogenic bacteria are not susceptible directly of causing difficulty with the preparation of Gruyère or Emmental cheese. A.H.J.

532. Volatile Acids of Cheese. II. Methods of Extraction. E. R. HISCOX, J. HARRISON, AND J. Z. WOLF, National Institute for Research in Dairying, Univ. of Reading, Shinfield, Nr. Reading, England. Jour. of Dairy Research *9*, 227–232, 1938.

A method for estimating the volatile acids in cheese based on the steam distillation of a water extract of the cheese is described. Considerably higher results were secured with this method than by direct steam distillation. S.T.C.

533. Volatile Acids of Cheese. I. Retentive Power of Cheese and Its Constituents. E. R. HISCOX AND J. HARRISON, National Institute for Research in Dairying, Univ. of Reading, Shinfield, Nr. Reading, England. Jour. of Dairy Research *9*, 215–226, 1938.

To determine the exhaustiveness with which the various acids could be recovered by steam distillation acetic, propionic, butyric, caproic, caprylic and lauric acid solutions with added cheese fat, butter fat, cheese protein and casein were steam distilled using a standard procedure. The fat portion of the cheese was found to have a retarding effect on the distillation of the higher volatile fatty acids. The cheese protein appeared to be capable of a permanent retention of a part of some of the acids present. The results indicate that a more accurate picture is gained of the distribution of the acids present by collecting only "twice the original volume" rather than by distilling to "5 times the original volume." S.T.C.

534. Chemical Changes During the Melting of Natural Cheese. M. KVETON, Polytechnic High School, Prague, Czechoslovakia. Le Lait *18*, 176, 561–575 (June, 1938).

There is little change in the properties of the butterfat in cheese as a result of melting in the presence of disodium phosphate or sodium citrate.

No significant change results in the Reichert-Meissl, Wauters Polenske or iodine values. The acidity of the fat is reduced slightly (on the average 2.5%) due to the melting in the presence of the alkaline salts. The soluble nitrogen is much higher in the melted cheese than in the natural cheese, increasing from about 11% of the dry matter in the natural cheese to about 40% in the melted cheese. The increase in soluble nitrogen is greater when disodium phosphate is used than when sodium citrate is used. The ash content of the melted cheese is higher than for natural cheese due to the added mineral salts. It is suggested that the higher ash content may be used to distinguish between natural and so-called "processed" cheese. The melting of the cheese increases the titrable acidity due to the effects of the alkaline salts on the proteins of the cheese. A.H.J.

535. Milk Organisms in Cheese Making. CONSTANTINO GORINI, Milan, Italy. Le Lait *18*, 177, 711–712 (July, August, 1938).

It is emphasized that milk organisms play a favorable role in the ripening of Gruyere and Emmental cheese because of their solubilizing action on casein. This group of organisms accordingly acts as activators for the lactic ferments. Gorini states that Dorner was incorrect in his conclusion that Gruyere and Emmental were not favorably affected by this group of organisms just as was the case for the other types of cheese. Even though organisms themselves might be destroyed in the process of cheese making, enzymes elaborated by them exert a favorable role in the maturing of cheese. A.H.J.

CHEMISTRY

536. The Determination of the pH of Lactic Acid Casein. JEAN PIEN AND M. WEISSMANN, Laboratories of the Farmers Union, Paris, France. Le Lait *18*, 175, 455–462 (May, 1938).

The pH of the casein solution may be used to indicate if the protein has been precipitated above its iso-electric point, if the washing has been incomplete and the casein thus contain casein lactates, and if the precipitation has taken place at a pH lower than 4.7. The solution is prepared for the determination of pH in the following manner: into a 100 cc. flask equipped with a ground glass stopper are added 50 cc. of twice distilled boiled water and 5 grams of casein. After shaking, the suspension was allowed to stand for 30 minutes if the casein was finely ground and for two hours if it was coarsely ground. The two hour period may be adopted for all caseins with shaking from time to time, if the flask is tightly stoppered. Toward the end of the soaking period, the flask is allowed to stand and the supernatant liquid decanted into the electrode vessel. The hydrogen electrode required a longer period to attain equilibrium than the quinhydron or the antimony

electrode in which cases equilibrium was attained immediately. Equivalent results were obtained with all these electrodes as well as with brom cresol green indicator. A.H.J.

537. Relationship of the Density in Dairy Products. JEAN PIEN AND G. MAURICE, Laboratories of the Farmer's Union, Paris, France. Le Lait *18*, 176, 582–610 (June, 1938).

Equations are developed from which the density of various dairy products can be calculated from a knowledge of the density of fat and solids-not-fat in the dairy product. A.H.J.

CONCENTRATED AND DRY MILK; BY-PRODUCTS

538. The Progress in Italy in the Fabrication of Synthetic Fibres Derived from Casein. G. GENIN, Engineer E.P.C., Paris, France. Le Lait *18*, 175, 481–484 (May, 1938).

Caseins originating from different sources are blended in proportions to give a uniform starting material. Water and other substances are then added and a viscous paste is formed. The fibres are formed by forcing the paste through holes 0.02 to 0.03 mm. in diameter. The casein fibres are coagulated and hardened by passing them through warm sulphuric acid. The acid in the fibres is then neutralized by immersion in an alkaline bath after which the fibres are cut into small bits which form the "flocks." The small branchlets are then immersed in a formaldehyde bath in which they remain for 10 to 15 hours. After washing and drying, the product is ready for spinning and weaving. The chief difference between the chemical composition of natural and synthetic wool is the sulphur content. The casein wool has a much lower sulphur content. It consequently is a superior insulating material than natural wool. Synthetic wool fibres when boiled with water for 3 hours did not lose weight. When boiled in an alkaline soap solution there was a small loss in weight, but less than that lost by treating genuine merino wool in the same way. Fibres are also made with mixtures of casein and cellulose (viscose used in the manufacutre of rayon) materials. It is suggested that such products be called "Serinlaine" when the percentage of casein is greater than the percentage of cellulose and "Rayonlaine" when the percentage of casein is lower than that of cellulose. The nitrogen content indicates the proportion of cellulose and casein in such products. A.H.J.

Other abstracts of interest are 536, 558 and 559.

DISEASE

539. The Effect of Subclinical Mastitis on the Solids-Not-Fat Content of Milk. S. J. ROWLAND AND M. ZEIN-EL-DINE, Department of Agri-

cultural Chemistry, Univ. of Reading, Reading, England. Jour. of Dairy Research *9*, 182–184, 1938.

The solids-not-fat content (expressed as percentage of the fat free milk) was determined for 247 samples of milk from individual quarters of 62 cows. The samples were also examined bacteriologically for the presence of *Streptococcus agalactiae*. Eighty-eight per cent of the samples below 8.80 per cent solids-not-fat were from infected quarters. S.T.C.

540. The Casein Number. A Chemical Method of Diagnosis of Mastitis. S. J. Rowland and M. Zein-el-Dine, Department of Agricultural Chemistry, Univ. of Reading, Reading, England. Jour. of Dairy Research *9*, 174–181, 1938.

Additional data on the accuracy of the casein number

$$\left(\frac{\text{percentage of casein N}}{\text{percentage of total N}} \times 100\right)$$

as a chemical method for the detection of mastitis are reported. The number was determined for 247 samples of milk from the individual quarters of 62 cows, and the samples were examined bacteriologically for *Str. agalactiae*. For the diagnosis of mastitis from the casein number, a figure of 78.0 and less was taken as indicating an infected quarter. The chemical results differed from the bacteriological for 21 out of a total of 243 quarters. The casein number was considered from this data to be a reliable diagnostic method. S.T.C.

541. The Incidence of Mastitis in Cows Yielding Milk Low in Solids-Not-Fat. A. S. Foot and P. M. F. Shattock, National Institute for Research in Dairying, Univ. of Reading, Shinfield, Nr. Reading, England. Jour. of Dairy Research *9*, 166–173, 1938.

An average of 19.5 per cent of the animals in milk in twenty-nine herds comprising 934 cows were found to yield milk low in solids-not-fat (below 8.5 per cent) as determined by analysis of the milk from two consecutive milkings at 5 to 6 week intervals during the first three months of 1937. Of the low solids-not-fat cows which were not stale, evidence of mastitis infection was found in an average of 61.5 per cent of cases. Evidence of mastitis infection was based on physical examination, positive brom-cresol test or bacteriological examination for the presence of *Str. agalactiae*. There were apparently at least twice as many subclinical cases of mastitis as clinical cases. S.T.C.

Other abstracts of interest are 542 and 560.

FEEDS AND FEEDING

542. Reproduction on Rations Free from Vitamin E. Byron H. Thomas

AND C. Y. CANNON, Iowa State College. Proc. Amer. Soc. Animal Prod. *30*, 59–63, 1937.

A suitable grain mixture and alfalfa hay were depleted of Vitamin E by treatment with an ether solution of ferric chloride and fed to goats in the proportion of 2:1. Over a period of 4½ years both males and females reproduced normally. These same feeds fed in various proportions to rats invariably produced symptoms characteristic of Vitamin E deficiency in this species. G.C.W.

543. Phosphorus Deficiency in Cattle as a Result of Conditions Other than Low Phosphorus Content of the Soil and the Feeding Stuffs Grown Thereon. E. B. FORBES AND S. R. JOHNSON. Proc. Amer. Soc. Animal Prod. *30*, 340–344, 1937.

Reports on a survey of cattle suffering from phosphorus deficiency in Pennsylvania with a description of environment, symptoms, and methods employed in bringing about recovery. G.C.W.

544. Lactic Silage with a Pasteurized Thermophile. CONSTANTINO GORINI, Milan, Italy. Le Lait *18*, 177, 673–681 (July, August, 1938).

Satisfactory silages are high in lactic acid, unsatisfactory silages are high in butyric acid. Lactic acid fermentations in silage are usually the result of proper conditions and temperature of the silage and absence of air. A more certain method of preparing satisfactory silage is to seed with a lactic acid producing organism. A Thermophile capable of producing lactic acid is recommended. In order to prepare silage with this organism, it is necessary to compress the silage uniformly and to control the temperature so that it rises to about 60° C (140° F) neither too slowly nor too rapidly. Silage prepared in this manner is eaten readily by cattle, and is green and fresh in appearance with a minimum of wilted and faded leaves. Such silage is usually high in vitamin content as it can be prepared from freshly cut material and can be taken from the fields wet with rain or dew. A.H.J.

545. The Preservation of Fodders by the Addition of Acids. JOEL AXELSSON, Upsala, Sweden. Le Lait *18*, 172, 216–220 (February, 1938).

The use of hydrochloric and sulphuric acids or mixtures of these acids (A. I. V. process) is more satisfactory for preserving silage than organic acids. Silage preserved with these mineral acids shows lower losses in nutritive ingredients during storage, is higher in its vitamin A content, and stimulates milk production. Legumes require more acid when made into silage than do grasses. The pH of acidulated silage should be 3.5 to 4.0. The use of acid operates to soften the woody tissues of the silage and

renders them more readily digestible. The flavor of milk from cows fed acidulated silage is equal to that of summer milk and the butter is also improved. However, such milk was not satisfactory for the production of Emmenthal cheese, but was excellent for the production of sharp flavored cheeses. A.H.J.

Other abstracts of interest are 554, 557 and 560.

FOOD VALUE OF DAIRY PRODUCTS

546. Stability of Vitamin D in Irradiated Evaporated Milk. C. H. KRIEGER AND H. T. SCOTT, Wisconsin Alumni Research Foundation, Madison, Wis. Food Research *3*, 3, 283, May–June, 1938.

There is little or no loss in the vitamin D potency of irradiated evaporated milk stored under average conditions for periods of two to three years, no loss whatsoever being noted after one year of holding.

F.J.D.

547. The Effect of Commercial Sterilization on the Nutritive Value of Milk. S. K. KON AND K. M. HENRY, National Institute for Research in Dairying, Univ. of Reading, Shinfield, Nr. Reading, England, with the collaboration of E. W. IKIN, National Institute for Research in Dairying, Univ. of Reading, A. E. GILLAM, Univ. of Manchester, Manchester, England, AND P. WHITE, Univ. of Reading, Reading, England. Jour. of Dairy Research *9*, 185–207, 1938.

V. The Effect of Commercial Sterilization on the Nutritive Value of Milk, K. M. Henry and S. K. Kon.

Fifteen samples of raw and fifteen samples of commercially sterilized milk from the same bulk were analyzed for vitamin C by the chemical method (titration with dichlorophenol-indophenol). The raw milk contained an average of 1.83 mg./100 ml. of total (reduced and reversibly oxidized) ascorbic acid. The corresponding figure for sterilized milk was 1.03 mg./100 ml., a loss of 43 per cent of the original value.

VI. Comparison of the Total Nutritive Value of Raw and Commercially Sterilized Milks, K. M. Henry, E. W. Ikin and S. K. Kon.

Paired feeding experiments with rats indicate that the total nutritive value of commercially sterilized milk is somewhat lower than that of raw milk and that vitamin B_1 is the first limiting factor. Rats getting limited but equal amounts of milk in addition to a basal diet which applied only protein, energy and minerals grow better on raw than on sterilized milk. The addition of 5 per cent brewer's yeast to the basal diet corrected this deficiency.

VII. Conclusions. S. K. Kon.

From the nutritional aspect sterilized milk has been shown to be inferior to raw or to pasteurized milk. Sterilization decreases slightly the biological value of the proteins, destroys half the vitamin C and 30 per cent of the vitamin B_1. S.T.C.

548. Groups of Milk. R. Dujarric dela Riviere and N. Kossovitch. Le Lait *18*, 474–481 (May, 1938).

Human milks contain α and β agglutinins for human red blood cells. Human milks may also be classified into 4 groups analogous to those of blood. The presence of iso-agglutinins is less regular in mother's milk (80.9% of the cases) than in their blood serum. The percentage of cases where iso-agglutinins are present in the milk is appreciably analogous for all groups (A:83.8; O:83.1). However, the percentage of group B is slightly higher (86.3). Mother's milk derived from the blood group AB (cases where the blood serum does not possess agglutinins) do not contain agglutinins; the red globules of group O (which are poor in agglutinogen) are never agglutinated by a lacto serum. The milk of group O$\alpha\beta$ always possesses the two agglutinins α and β more or less strongly. Agglutinin α in general acts more strongly than agglutinin β. Divergence between the agglutinins of blood serum and the agglutinins of milk serum of the same mother had not been found. Relation between anaphylactic shock and "group" of the milk ingested or between tolerance for milk and the group of the milk ingested have not been worked out. However in 31 cases where nutritional difficulties were being experienced with milk, it was found that the blood groups of the infant were different from the milk group of the nurse. A.H.J.

549. New Aspects of Lactic Therapy. Jean Pien, Chemical Engineer, Director of the Laboratory of the Farmers Union, Paris, France. Le Lait *18*, 177, 699–711 (July, August, 1938).

Biochemical and clinical manifestations of intestinal intoxication due to harmful intestinal flora are reviewed. Milk organisms by which such situations may be corrected are discussed. Lactic therapy demands that ferments be present which can grow in the intestine, that only living organisms of strong virulence be employed, and that the numbers of living organisms in the cultures used be high. A.H.J.

550. A Physico-chemical Theory of Artificial Infant Feeding. L. Pikler, Budapest, Hungary. Le Lait *18*, 177, 681–698 (July, August, 1938).

The author discusses the changes in colloidal and ionic conditions of cows milk that takes place as a result of the various modifications that are

accorded it in making it satisfactory for infants. Among the various treatments of milk discussed are boiling, skimming, dilution with water, addition of acids, addition of alkali, addition of salts particularly calcium salts and citrates, addition of sugar, saccharose, dextrinized flour, malt, and boiled gruel of barley, rice and oats, and the addition of dried protein, of gelatin and of gums. The effects on milk of various enzymes such as rennin, lactase, pepsin, other proteolytic enzymes, and milk lipase and stomach lipase are also discussed. The effects of these additions on osmotic concentrations and properties of the proteins, particularly of the casein, are emphasized. One hundred twelve literature citations are given.

A.H.J.

ICE CREAM

551. Ice Cream Sales Index. An Analysis of Ice Cream Sales in 1938. ANONYMOUS. Special Bulletin of the Inter. Assn. of Ice Cream Mfrs., 1105 Barr Bldg., Washington, D. C., August, 1938.

Sales of ice cream for the first four months of 1938 are compared with the same four months of 1937. For the United States, the first four months of 1938 showed increased sales. In Canada the increase for the four-month period over that of the first four months of 1937 was 6.43 per cent.

The completed survey of ice cream sales for the full year of 1937 shows the gallonage to be the greatest of any year in the history of the industry.

M.J.M.

MILK

552. The Suitability of the Cremometric and the Phosphatase Tests in the Supervision of Holder Pasteurized Milk. JOHANNE E. JACOBSEN, Royal Tech. College, Copenhagen. Zeitschr. Untersuchung der Lebensmittel *71*, 515–521, 1936.

Both reactions can be used to indicate if milk has been heated to 62–63° C for half an hour. The phosphatase test has certain advantages over the cremometric test: (1) Homogenization has no influence on the results; (2) it can be used also on cream and skimmilk; (3) a small admixture of raw milk to pasteurized milk can be detected. However, in certain respects the cremometric test is to be preferred: (1) It does not use expensive and poisonous chemicals; (2) it is so easy to carry out that any dairy can use it; (3) finally it shows if the milk has been overheated. J.C.M.

Author's Note: The cremometric method is not used in the United States as it depends upon cream layer reduction at temperatures higher than those required in the United States. In Denmark milk is generally heated to 62° C (145.4° F.) or higher.

553. How Can the Cities Be Supplied with Good and Cheap Milk. S. ORLA-JENSEN, Royal Tech. College, Copenhagen. Maelkeritidende *50*, 157–165, 1937.

The author advocates the double safeguard offered by compulsatory pasteurization, *e.g.*, 63° C., 30 min. and vigorous veterinary control of all market milk; also cream should be pasteurized. Specially to be recommended is the pasteurization in bottles, already practiced in about 400 smaller dairies in Denmark. The bottled milk should not be distributed by each individual milk company, but by a centralized distribution agency in order to cut down the cost of distribution. J.C.M.

554. Variations in the Protein Content of Milk During Lactation. E. AZARME, Institute of Animal Genetics, Univ. of Edinburgh, Edinburgh, Scotland. Jour. of Dairy Research *9*, 121–146, 1938.

The total protein nitrogen and the casein nitrogen were determined in about 380 weekly samples of milk taken from twenty-seven individual cows of different breeds and at different stages of lactation during a period of about 6 months. The albumin plus globulin nitrogen was calculated in each case by difference. It was found that the percentage of total protein nitrogen decreases very significantly from the beginning until the 4th week of lactation, and then rises slowly until the end of lactation, the rise being more pronounced towards the end. The same was true for casein nitrogen and for albumin plus globulin nitrogen, but with the latter only the decrease at the beginning and the rise at the end was sharp. S.T.C.

555. The Milk of the Goat under English Conditions. FRANK KNOWLES AND J. E. WATKIN, East Anglican Institute of Agriculture, Chelmsford, England. Jour. of Dairy Research *9*, 153–165, 1938.

An account is given of observations made for over two years on the yield and composition of the milk of the breeds of goats distributed throughout Great Britain. In all 2662 samples from 345 animals of 8 breeds were analyzed. The average analyses reported are as follows: fat, 4.50 per cent; solids-not-fat, 8.68 per cent; lactose, 4.08 per cent; total proteins, 2.90 per cent; casein, 2.47 per cent; albumin and globulin, 0.43 per cent; non-protein nitrogen, 0.44 per cent; ash, 0.79 per cent. The average milk yield of the officially recorded goats in Great Britain was shown to be about 7½ pounds per day. S.T.C.

556. The Milking Pail of Jens Grand. S. ORLA-JENSEN, Royal Tech. College, Copenhagen. Maelkeritidende *50*, 1039–1041, 1937.

The practice of milking directly down upon solid carbon dioxide to cool milk effectively has not been found to have any value. Such large quantities

of CO_2 are needed that the milk gets a disagreeable flavour. The bacteria present are not inhibited under these conditions, some are even favoured in their development.

The value of filling milk pails with gaseous carbonic acid is thus open to doubt. The favorable results obtained with the device of Jens Grand are probably caused by the careful sterilization and handling of the apparatus and not by the presence of CO_2. J.C.M.

557. Errors Involved in the Estimation of the Lactation Yield of Protein According to the Intervals between Sampling. E. AZARME, Institute of Animal Genetics, Univ. of Edinburgh, Scotland. Jour. of Dairy Research *9*, 147–152, 1938.

An attempt was made to determine the frequency of sampling necessary to estimate accurately the lactation yield of protein. For practical purposes sampling every two weeks during the first 6 weeks and the last 4 weeks of the lactation and every three weeks for the remainder was considered sufficient. S.T.C.

Other Abstracts of interest are 522, 523, 524, 537, 539, 541, 546, 547, 548, 550, 558, 559, 560.

MISCELLANEOUS

558. Problems which Remain to Be Solved in the Dairy Industry. G. GENIN, Chemical Engineer E.P.C., Paris, France. Le Lait *18*, 176, 610–614 (June, 1938).

Problems dealing with the production of fluid milk, condensed milk, ice cream, cheese, the fabrication of dairy equipment, and the disposal of dairy wastes are discussed. A.H.J.

559. Treatment of Waste Water from the Dairy. G. GENIN, Engineer E.P.C.I., Paris, France. Le Lait *18*, 177, 711–714 (July, August, 1938).

Loss of milk in the wash water of the dairy averages ½ to 1% of the milk passing through the plant. For cheese factories and creameries the losses run from 3% to 8%. Such losses in the dairy wastes going into streams are responsible for considerable pollution. Rather than require expensive waste disposal plants, it is suggested that efforts be made to keep concentrated wastes from going into the wash water. This may often be done inexpensively by modifying existing equipment or processes and by exercising care in the saving of possible usable dairy wastes and in the cleaning of equipment. A.H.J.

PHYSIOLOGY

560. Secretion of Milk. DWIGHT ESPE, Iowa State College, Ames, Iowa. Published by Collegiate Press, Inc., Ames, Iowa. Price $3.00.

This book was designed as a text for a course in Milk Secretion in which the principal objective is the application of the fundamental training received by the student in Anatomy, Physiology, and Nutrition to the problems dealing with the normal functioning of the mammary gland.

The material covered is well organized into three parts. Part one deals principally with the anatomical aspects of the subject, part two with the physiological, and part three with the nutritional.

The subject matter is clearly presented and should be found readable by those for whom the book is intended. This work provides a much needed text and reference work for the undergraduate student in dairy production.

The author has used a wealth of reference material and a bibliography of 695 references is appended. While the book was not designed for the research worker, the generous use of the literature makes this a useful book for the library of the investigator.

The author has made generous use of illustrative and tabular material, there being forty-nine illustrations and thirty-four tables. T.S.S.

Other abstracts of interest are 539, 541, 554, and 557.

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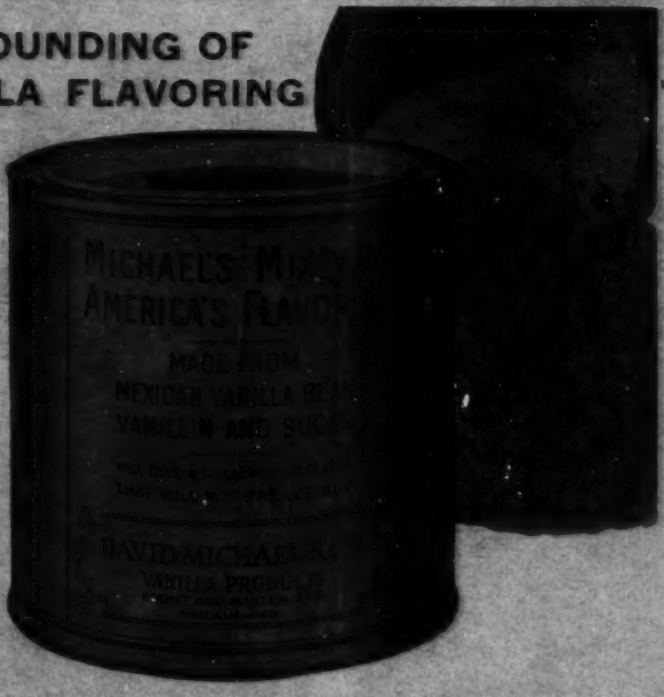
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